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A CONTRACT FOR A 30-IN. STEEL FORCE MAIN, at Atlantic City, N. J., has been awarded to the T. A. Gillespie Co., of Pittsburg, Pa., for $130,000. The main will be 27,300 ft. long and will be laid across the meadows, to connect one of the pumping stations with the city. As stated in our issues of Oct. 4 and Nov. 1, 1900, the water commissioners, on recommendation of their superintendent, Mr. W. C. Hawley, Assoc. M. Am. Soc. C. E., and their consulting engineer, Mr. Emil Kuichling, M. Am. Soc. C. E., advised the use of wooden stave pipe, but the city council required specifications and bids for wooden, steel and cast-iron pipe. The contract price for steel pipe in place was $130,000, while the total of the lowest bids for furnishing and laying cast-iron pipe, treated with mineral rubber coating, was $146,684. The only bid for wooden stave pipe (under this plan) was also from the T. A. Gillespie Co. (who thus bid against itself), and was $133,000. There was a bid for ordinary tar-coated cast-iron pipe, which, with the lowest price for laying cast-iron pipe, would have amounted to a total of $129,000, for the pipe in place, or slightly less than the bid for steel, but it was considered unwise to use tar coating, particularly as mains now laid across the meadows, coated with that material, "can be cut into," according to Mr. Hawley, "in many places to a depth of ⅛-in., the metal having deteriorated until it is very much like graphite." The figures given above do not include cast-iron specials and two parallel 20-in. lines of submerged cast-iron pipe with ball joints, each 565 ft. in length, which may be ignored in comparing the relative prices of the different classes of material for the main line. Under another set of specifications for a low-pressure instead of a high-pressure force main, "the wooden stave pipe would have been many thousand dollars cheaper than steel," Mr. Hawley states. The steel pipe will be treated with mineral rubber coating, after which, the specifications provide, it must "be wrapped with at least one thickness of burlap, which must be so put on as to adhere firmly to the coating." This extra protection was suggested by Mr. Kuichling. Mr. Hawley says that in laying the pipe he expects to lower it into the trench in 112-ft. sections, on each end of which there will be a flange. These flanged joints will be riveted and calked from the outside, so it will be unnecessary to enter the pipe after it is once in the trench.

THE USE OF ARMED-CEMENT where it is exposed to sea water is discussed in the "Annales des Ponts et Chaussees." Experiments prove that the cement is not a sufficient insulator and will not protect the iron indefinitely. And further, the protection of the surface by heavy oils or tar compounds will only retard the destructive effect without stopping it. All organic matter used as a protection will surely disappear in time. The author says that there is, however, an advantage and economy in using the armed-cement where indefinite duration is not necessary; such as accessory works, the protection of masonry against washing out and to replace wood or metal in certain sea works.

THE INFLUENCE OF COPPER IN REDUCING CORrosion of iron and steel was recently tested by Mr. F. H. Williams, of Wheeling, W. Va., and the results were reported to the Chemical Section of the Engineers' Society of Western Pennsylvania on Sept. 20. While the experiments were on too small a scale to be conclusive, they indicated that small quantities of copper, less than 0.4%, in iron and steel may reduce the rate of corrosion to half or a third of the amount that would occur in material without the copper.

THE INTERMITTENT FILTRATION OF SEWAGE at New Britain, Conn., has been recommended by the sewer commissioners in a report including an outline of plans and an estimate of cost, by Mr. W. H. Cadwell. This plan was recommended, we understand, several years ago by Mr. S. M. Gray, M. Am. Soc. C. E., of Providence, R. I. The cost of filter beds is estimated at $91,455, and the cost of the necessary outfall sewer is placed at $73,725. In addition separate sanitary and storm sewers must be provided in place of some combined sewers now in use and the sewers must be extended, if the city is to be served properly, all of which it is estimated will cost $246,288, making $411,408 in all. This figure would be raised to nearly $450,000 by providing for the sewerage of a district outside the city. The city must adopt this or some other scheme soon, it would appear, on account of the many damage suits being brought against it for stream pollution.

AN ALLEGED DISCREPANCY of $4,107,372 between the value of metered water and the revenue therefrom in New York city for the eleven years 1879 to 1890, is claimed by Mr. Frederick B. De Berard, in a report made to the Merchants' Association of New York, on Nov. 21, 1900. That is, the total metered consumption for the period, as reported by the chief engineer, was worth $11,246,162, at the prevailing rate of $1 per cu. ft., but the water registrar accounted for only $7,138,790, including both collections and amounts returned as in arrears. Mr. De Berard says "that if the deduction" from his figures "is mistaken, then the official data are misleading and worthless," and "that if the data are sound then the city has lost $4,000,000." The association has appointed a committee to consider the report. It is idle to pass upon the allegation until an official statement has been issued by the city authorities. Copies of the report may be obtained on request, we presume, by enclosing name, address and postage stamp to the Merchants' Association, 346 Broadway, New York city.

THE LAKE BORGNE CANAL, which will soon be completed, will connect Mississippi Sound and the Alabama Rivers with the Mississippi River at New Orleans. It will be used in connection with the new whaleback steel barge line, of the St. Louis Steel Barge Co., now operating between St. Louis and New Orleans. It is expected that the new canal will provide an important outlet for the lumber regions of Mississippi and Alabama, and have an important bearing on the lumber business of St. Louis and Chicago. The barge company also proposes to so reduce its rates as to divert much grain to New Orleans for shipment.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Plant System near Burroughs, Ga., on Nov. 20. During a dense fog a freight train ran into another freight train which was taking a siding in order to allow the first train to pass. Two men were killed and two were injured.

DROP TESTS OF DRAFT GEARS FOR FREIGHT cars were described by Mr. R. P. C. Sanderson, Asst. Supt. of Machinery of the Atchison, Topeka & Santa Fe Ry., at the November meeting of the Western Railway Club. The drop weight was arranged to give a jerk to the gear similar to that which it experiences in train service. The regular 1,640 lb. drop weight was used and the gears were given 27 blows with 5 ft. to 10 ft. height of fall. This height was then increased 1 ft. at each blow till 20 ft. was reached, and the test concluded with three blows at 20 ft. The blow at 5 ft. was sufficient to compress the draft springs in the gear solid. Nine different styles of draft gear were tested, all of which suffered more or less damage. Several of them, however, stood up well enough under the tests to warrant the belief that they would give good service on the new large capacity cars that have recently been designed.

THE SOUTHERN MANCHURIA RAILWAY, for a distance of about 180 miles, has been destroyed by the Chinese, according to a despatch of Nov. 19 from Vladivostock. All the stations were burned and much rolling stock destroyed. The loss is estimated at 10,000,000 roubles. Another despatch from Tong-Kee says that the railway from that point to Shan-hai-Kwan will require at least two months' work to put it in order, after the material is received, as about 38 miles of track have been destroyed. In some cases the roadbed has been torn up and the ties burned. The rails have generally disappeared. The iron bridge over the Peh-tang River is so much damaged as to practically require reconstruction, and the abutments are weakened by the use of explosives. The line from Tang-tsun to Pekin is being slowly rebuilt, but material of all kinds is very scarce. The railway from Tientsin to Pekin will be open again by the end of December.

THE ALBANY & HUDSON RAILWAY & POWER CO. formally opened its electric surface line on Nov. 22, the road running from Hudson, N. Y., to Rensselaer or East Albany. The power is generated at Stuyvesant Falls, on Kinderhook Creek, about 10 miles north of Hudson, where a fall of 104 ft. was utilized to operate three double turbines, securing 6,000 HP. The line was made up by buying the old Kinderhook & Hudson Ry. and the Greenbush & Nassau Ry., and connecting them. The line is broad gage and is operated on the third-rail system, and it is proposed to carry both freight and passengers. The entire cost is estimated at $3,100,000, and the chief promoters were Mr. Chas. Cooper and Mr. Alden M. Young, of Brooklyn, and Mr. R. A. C. Smith, Henry G. Runkle and others, of New York.

COMPETITIVE ENGINEERS' PLANS FOR UTILIZING water power at Christianna, Sweden, are asked for. Three awards of $8,000, $3,000 and $2,000 will be made for the best plans, and full particulars can be obtained by applying at the office of the Water Engineer, Kjeld Stubs Gade, No. 1, Christianna, enclosing $6 for the plans. Propositions will be received until 2 p. m. Jan. 15, 1901.

THE LAKE SHIPBUILDERS PROPOSE TO BUILD ocean steamships of any length, the plan being to build the vessels in sections suitable in length to pass the locks of the Canadian canals and then to put the sections together at Montreal. The first ships to be constructed are to be 350 ft. long, 43 ft. beam and 20 ft. deep, but plans are being drawn for ships up to 650 ft. in length. Bulkheads on the transverse center line will enable the 350 ft. ships to pass to Montreal, the after part containing the machinery being supposed to be in working operation and to tow the forward part.

THE BUREAU OF YARDS AND DOCKS, through Rear Admiral M. T. Endicott, Chief of Bureau, reports that to continue the work of improving the navy yards during the next fiscal year will cost $12,456,390. All the dry docks authorized by Congress in March, 1899, are in progress, and the floating dry dock for Algiers, La., now building at Sparrow's Point, Md., will probably be floated and towed to its destination next spring. Speaking of dry dock No. 2, at the Brooklyn Navy Yard, Admiral Endicott says that the repairs on this dock will probably be completed by the end of this year, when the former wooden dock will be practically transformed into a concrete dock with a wooden floor. The original cost of this dock, as "completed" in 1890, was $595,000; the repairs and renewals will cost about $600,000. He cites this dock as an example of the unwisdom of using perishable materials in these important works, for while the original cost is smaller, the ultimate cost is vastly greater and the risks and dangers involved are unwarranted.

SEACOAST STORM SIGNALS to warn those off the coast of impending storms, are to be established along the Atlantic coast and Great Lakes by the Weather Bureau. The bureau has been experimenting with signal lamps for some time, and it has adopted American lamps with pressed glass lenses, which will be mounted upon lofty steel towers. Each beacon will be visible about 12 miles in any direction, and about 108 of them will be set up.

THE REPORT OF THE SECRETARY OF THE NAVY asks the next Congress for two battleships and two armored cruisers, all of the maximum displacement, and for at least six light gunboats, two destroyers, three torpedo boats and one transport and two training ships. He also announces the armor contracts ready to be signed, already noted in this journal. For vessels now under construction he asks for an immediate increase in the navy personnel of not less than 5,000 men, the Department to train its own men from among recruits between the ages of 21 and 26 years. Since the date of the last report the following vessels have been finally or conditionally accepted: The battleship "Alabama," "Kearsarge," and "Kentucky"; the protected cruiser "Albany," four gunboats formerly of the Spanish Navy, the torpedo boat "Craven" and the submarine boat "Holland." The first of the new 40-caliber 12-in. guns have been tested with the result that 360 lbs. of smokeless powder gave a muzzle velocity of 2,854 ft. seconds, and a muzzle energy of 47,994 ft. tons, with a projectile weighing 850 lbs. The 12-in. guns now in service have a muzzle velocity of 2,300 ft. seconds, and a corresponding energy of 31.170 ft. tons. Of the armor heretofore contracted for the manufacturers have delivered 2,869 tons, leaving 1,437 tons still to be delivered. The eight battleships, six armored cruisers and three protected cruisers, already authorized by Congress, will require 36,810 tons of armor to be contracted for. The total estimates for 1892 aggregate $87,172,630, as compared with $65,130,916 for 1901; of the first amount $9,241,837 are new items, including $6,693,200 for the Bureau of Yards and Docks.

EXPERIMENTS ON THE EXPLOSIVE POWER OF ACETYLENE GAS.*

By Robert H. Fenn.†

Since the discovery of a cheap method of manufacturing carbide of calcium, acetylene gas, which is generated from it, has become a commercial factor as a source of illumination, and it was deemed of interest to determine its explosive force.

Like nearly all other inflammable gases, acetylene will not explode unless it is mixed with a certain percentage of oxygen. The air contains 20% of oxygen, so that it suffices to mix with acetylene five times as much air as there is oxygen required, and an explosive mixture will be formed.

Figs. 1 and 2 show an apparatus which was designed and constructed at the Clarkson School of Technology, Potsdam, N. Y., to test the pressures of exploding mixtures of gas and air. Referring to Fig. 1, the cylinder A, the screw B which transmits the pressure to the bearing C, and the supporting parts were all designed to carry with safety a pressure of 1,000 lbs. per sq. in.

In the interior of the cylinder A is a piston with cast-iron and fiber packing rings. The pulley D is threaded on the inside to fit the screw B, so that when D is revolved the screw and piston move in or out at will and give both a means of changing the volume of the cylinder, and of putting an initial pressure upon the imprisoned gas. At LL are stop-cocks for admitting air and exhausting the burnt gases from the cylinder after an explosion. M is a stop-cock for admitting gas; N a gage reading to 100 lbs. per sq. in., and used for measuring initial pressures; O, a sparking device connected to the induction coil R for exploding the gas; Q, a Crosby Gas Engine Indicator, using a 300-lb. spring with the barrel belted to a revolving shaft overhead, giving a card with a continuous line for the rise and drop of pressure; S is a thermometer placed in a well; but it was not used because of the great absorption of heat by the mass of iron in the cylinder and piston. P is a small generator in which the acetylene was produced as required; P_2, a bottle calibrated so that 500 cu. cm. of gas could be accurately measured; P_3, a bottle holding water which displaces the gas in P_2 when it is desired to inject it into the cylinder.

The cylinder A was so calibrated that for each ½-liter of volume there was a corresponding mark upon the screw B. Thus, if it was desired to have a mixture of 9 parts of air to 1 of gas the piston was set so that the mark 4.5 liters came under the index; then the gas receiver was connected to M and the piston was pulled out till the 5-liter mark came under the index. The gas rushed in to fill the partial vacuum, all of the other stop-cocks being closed. When the half-liter of gas had been injected the stop-cock was shut off at M and the mixture was ready for an explosion. If, however, an initial pressure was desired in exploding, the pulley was revolved before explosion, driving the piston into the cylinder and compressing the mixture until the desired pressure was indicated by the gage N. The mixture was then exploded, and the pressure was registered upon the card of the indicator from which it could be read by a scale. The first series of tests were made at atmospheric pressure for the initial pressure, and with mixtures of air and acetylene ranging from 15 parts air to 1 part acetylene to 3 parts air to 1 part of acetylene. The 3 : 1 mixture showed very markedly the poor combustion due to lack of air, a heavy black soot being driven from the cylinder on exhausting.

The results of the tests are shown in Diagram I. It will be seen that the most explosive mixture has a ratio of air to gas between 8 : 1 and 10 : 1. Subsequent experiments showed that a mixture with a ratio of 9 : 1 gave the greatest explosive power.

A series of tests were then started in which initial pressures ranging from 0 to 35 lbs. were to be used, with ratios of air to gas ranging from 7 : 1 to 11 : 1. The results are shown in Diagrams II. and III.

In order to make a comparison between acetylene and some gas better known, a series of tests were made upon gas generated from gasoline and taken from the supply pipes in the school building, where it was used both for illuminating purposes and for fuel. Diagram I. shows the curve derived from tests at atmospheric pressure. A ratio of 4 : 1 gave the greatest pressure on exploding. Several tests were then made, with ratios of 4 : 1 and 5 : 1 and varying initial pressures. The results are shown in Diagram II.

A comparison of the curves for the most explosive mixture of acetylene and air and vaporized gasoline and air, taking the case of 20 lbs. initial pressure upon each and for equal quantities of gas, shows that acetylene produces a pressure $\frac{273}{165}$ greater than that produced by vaporized gasoline. Furthermore, the ratio of air to acetylene was 9 : 1, while that of air to vaporized gasolineline was 4 : 1. Therefore, to obtain the same power by the use of acetylene, and that given by gasoline, at these ratios, the total volume of acetylene mixture would be halved to correspond to the volume of the vaporized gasoline mixture. Then, since acetylene will give a pressure $\frac{273}{165}$ higher than gasoline gas, the volume of the mixture may yet further be reduced, or $\frac{1}{2} \times \frac{165}{273} = 0.304$ of the volume of the gasoline gas mixture. Therefore, for example, if ½ liter of vaporized gasoline be used to do a certain amount of work at an initial pressure of 20 lbs. per sq. in., to obtain the same amount of work using acetylene gas, only .304 of ½-liter, or .15-liter, would be required using the given ratios of air to gas.

Diagram IV. shows two theoretical indicator cards, one for acetylene gas (ratio of 9 : 1), and one for gasoline gas (ratio of 4 : 1), each represent the relative work of the two gases. The initial pressure was 20 lbs. in each case, and the line of impressed work is shown in each card (V W) for acetylene and (X Y) for gasoline.

Measuring the area of the diagrams by means of a planimeter, the acetylene diagram measured 4.91 sq. ins., and that of the gasoline 1.79 sq. ins.,

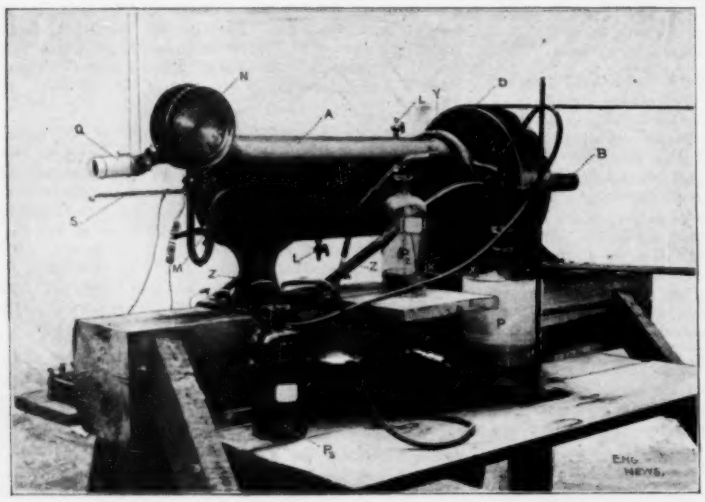


Fig. 1.

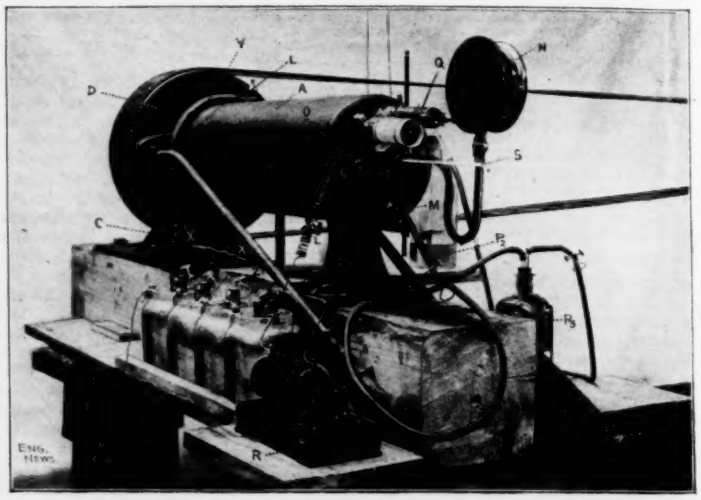


Fig. 2.

APPARATUS FOR TESTING PRESSURE OF EXPLOSIVE MIXTURES OF ACETYLENE GAS.

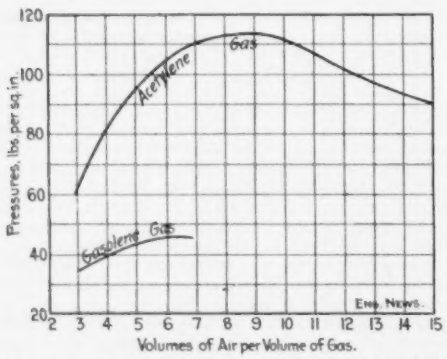


Diagram I.—Pressures of Exploding Mixtures of Gas and Air. Exploded from Atmospheric Pressure.

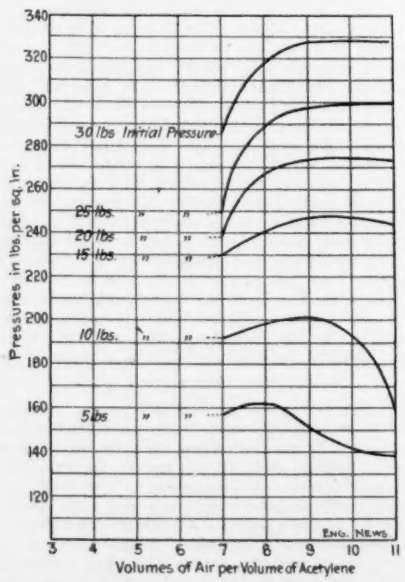


Diagram III.—Pressures of Exploding Mixtures of Acetylene and Air, Exploded from Various Initial Pressures.

*Condensed from a Graduating Thesis presented by the Author at the Clarkson School of Technology, Potsdam, N. Y.

†836 Halsey St., Brooklyn, N. Y.

giving a ratio of power of acetylene to gasoline of 4.91 to 1.79, or nearly 3 : 1.

Both gases, when they exploded, did not register their full theoretical explosion pressures, because between the beginning of the explosion and the point of maximum pressure an appreciable length of time elapses and a large quantity of the heat is absorbed by the iron about the gas, thus reducing the maximum pressure, which is a function of the heat evolved by the explosion. As gasoline gas acts more slowly than acetylene, the practical test

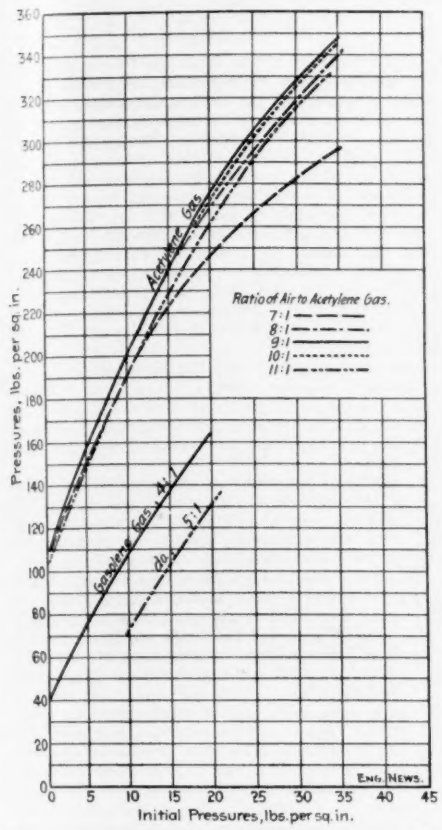


Diagram II.—Pressures of Exploding Mixtures of Gas and Air of Varying Richness and Varying Initial Pressures.

makes acetylene (ratio of 9 : 1) 3.28 times as powerful as gasoline (ratio of 4 : 1), whereas theoretically it should be only 3 times as great.

The acetylene used in the experiments was of the ordinary commercial quality used directly from the generator without being dried, and had a calorific power of about 1,350 h. u. per cu. ft. The gasoline gas was of the best quality drawn directly from the mains, and had 700 or more heat units per cu. ft.

In Diagram V. is shown two sample indicator cards, of acetylene and gasoline explosions. The abscissas represent equal spaces of time, while the ordinates represent pounds pressure per sq. in. From these cards it will be seen that the action of acetylene is far more rapid than gasoline gas. The space from O to P in each card represents the relative length of each explosion from start to maximum. This sudden and very rapid rise in pressure with the acetylene might be detrimental to engine cylinders and working parts, acting as a sudden shock of great intensity.

It was found, however, that if a greater quantity of air be mixed with the gas, for example, a ratio of 15 parts air to 1 of acetylene, the rapidity of the explosion was reduced so that it took 2½ times as long as when the 9 : 1 ratio was used. But this caused a loss in the maximum pressure of 20%. This loss is due to the introduction of the 6 parts of air which are inert, and which dilute the gas, cutting down the rapidity of the explosion, so that it compares favorably with gasoline gas, acting only 1-5 faster.

It was impossible to explode an 8 : 1 mixture of air and gasoline by means of the spark. The acetylene has an advantage in this respect, a 15 : 1 mixture exploding as readily as a 9 : 1.

Considering unit quantity, say 1 cu. ft. each, of a 15 : 1 mixture of air and acetylene and a 4 : 1 mixture of air and gasoline gas, the first on explosion at atmospheric initial pressure would give a pressure of 90 lbs. per sq. in., the second a pressure of 43 lbs., as will be seen by referring to Diagram I. Allowing each to expand adiabatically to 10 cu. ft. the external work in each case would be calculated by the following equation:

$$W = \frac{P_1 V_1}{K - 1} \left\{ 1 - \left[\frac{V_1}{V_2} \right]^{K-1} \right\}.$$

In which W = the external work; P_1 = the absolute pressure of the gas; V_1 = volume before expanding; V_2 = volume after expansion; K = 1.405.

Substituting in the equation the given values; for acetylene W = 22,403 ft.-lbs., and for gasoline W = 12,132 ft.-lbs. But only 0.0625 cu. ft. of acetylene was used, while 0.20 of a cu. ft. of gasoline gas was needed, or 3.2 times as much.

Now substituting in the same equation: W = 12,132, P_1 = 104.7, V_1 = X, V_2 = 10, and solving for X, a value of .54 is obtained; this is too great, however, as would be seen by substituting it for V_1 and solving the equation for W, the result would be greater than 12,132 ft.-lbs. Assuming, then, that X = 0.5, and resubstituting this value in the equation for V_1, the external work corresponds approximately to that of 1 cu. ft. of gasoline gas, or to produce the same amount of external work only .5 of a cu. ft. of acetylene mixture (15 : 1 ratio) is required.

Therefore, from the two foregoing determinations, it is seen that with the given ratios, only 0.0312-cu. ft. of acetylene gas is required to do the same work that 0.20-cu. ft. of vaporized gasoline will do. Or comparing equal quantities of the two gases, acetylene has about 6.5 times the intrinsic energy of vaporized gasoline at the given ratios of air and gas.

Assuming an engine with a total efficiency from crude fuel to useful work of 15%, and a consumption of 22 cu. ft. of gasoline gas per horse-power per hour, the cost of 1 horse-power per hour would be 1.3 cts., at 58 cts. per 1,000 cu. ft. of vaporized gasoline. The cost per horse-power per hour for

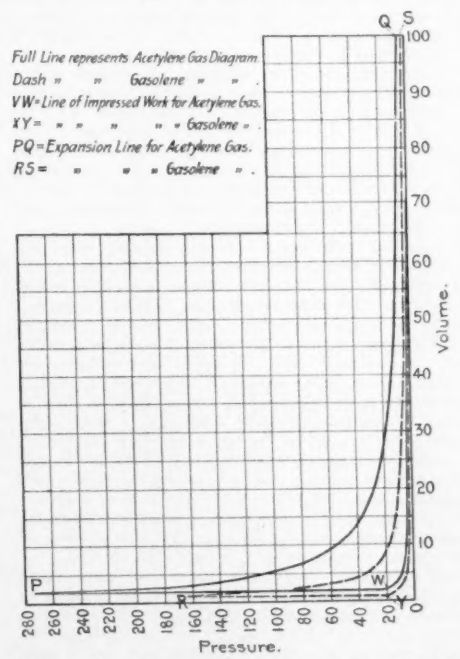


Diagram IV.—Theoretical Indicator Cards of Acetylene and Gasoline Explosions.

acetylene in an engine of equal efficiency would be 2.6 cts., with calcium carbide costing $70 per ton, or acetylene $8 per 1,000 cu. ft.

To do the same amount of work with acetylene in place of vaporized gasoline, therefore, would be about twice as expensive. For this reason acetylene would only be of practical use to produce power in places where light compact engines were required, as in automobiles. In the event of a 50% reduction in the price of calcium carbide, however, it might probably come into more general use for gas engines.

ELECTRICAL EXHIBITS AT THE PARIS EXPOSITION OF 1900.*

By Carl Hering,† M. Am. Inst. Elec. E.

Among the classes of exhibits of well-developed industries, there were three in particular which may be mentioned here specifically, as each marks a distinct and important direction of development, and was exhibited for the first time very prominently at a large international exhibition. They are the automobile, the incandescent gas lamp (known here as the Welsbach), and the three-phase generators, motors and systems. The automobile exhibit

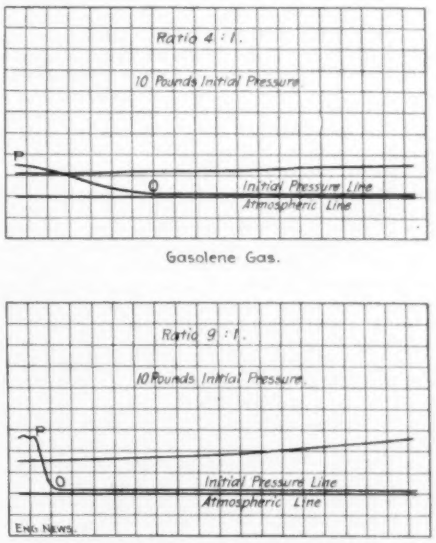


Diagram V.—Typical Pressure Curves During Explosion of Acetylene and Gasoline.

was very large, but unfortunately for the electrical industry, it seems that the gasoline vehicle is gaining very fast in the race with the electric. In Paris where automobiles are being used quite extensively, the quiet but heavy electric vehicle is seen only occasionally, while the light but noisy and malodorous one using gasoline, is heard and smelt very frequently. The incandescent gas lamp was used in large numbers on the Champ de Mars, the only large open area in the exhibition, where arc lights would otherwise have been installed. Even the friends of the electric light must admit that the illumination produced by it was very effective, brilliant and white without being dazzling. This lamp is getting to be a very serious competitor to the electric light, and some of the European central stations, particularly in the home of its birth, Austria-Hungary, are having serious difficulty in competing with it.

THREE-PHASE GENERATORS.

One of the striking features was the great prominence of three-phase generators, and their size. One obtains the impression that the three-phase current has triumphed over all the others, including the continuous current, when large amounts of power are concerned, and that it would be poor practice now to install large units of any but the three-phase system unless one is forced to use another. There was shown a decided tendency toward the use of large units, and quite a number were exhibited having outputs of about 1,000 kilowatts and over. The greater number were for three-phase currents and all formed the flywheel of their direct-connected slow-speed engines, while all of the few large continuous current machines exhibited, had to have a separate flywheel. That the field is made the revolving part seems to be almost universal practice, as also the distributed winding on the armature. Single and two-phase alternators and large continuous current machines were the exception.

The largest generator exhibited was a 72-pole, 3,000 K-W. three-phase machine, of the Allgemeine Elektricitaets Gesellschaft of Berlin. Its speed was 83, frequency 100, voltage 6,000, weight about 160 tons, and diameter of revolving field about 24 ft. As many as 21 of these are under construction. It was claimed to be the largest in the world, but this is an error, as generators of 4,000 K-W. and over are in use in this country at even slower speeds. Several others above 1,000 K-W. were shown, the slowest speed being 72, of the 2,700 K-W. mixed single and three-phase current Helios machine.

The direct generated voltages of the three-phase machines was from 2,000 to 6,000 volts; there was one exhibit of a comparatively small generator for 30,000 volts, but as long as good transformers can be bought, such ex-

*Extracts from the inaugural address of the author as President of the American Institute of Electrical Engineers.

†929 Chestnut St., Philadelphia.

cessively high voltage machines will probably be used only for exhibitions and laboratories.

There were a number of inductor alternators exhibited, which indicates that they are meeting with some favor.

Connecting lamp circuits to three-phase generators does not seem to be considered a sufficiently serious matter to overbalance the advantages of that system. The method used by the General Electric Co. of Berlin (that is, the Allgemeine Elektricitaets Gesellschaft, which even in Germany is generally abbreviated to A. E. G.) is simply to distribute the lights as evenly as possible over the three branches. All three mains are run into the buildings of even small consumers, although only two may be used, the third being available for changing over a batch of lamps, if necessary, for balancing. The voltage can thus be regulated only for all three branches together, and not for each separately; but this is not considered a serious disadvantage. The Oerlikon Co., on the other hand, connects lamp circuits between the ends of only two of the three branches of a star-connected winding, the third branch being then idle; this enables the voltage of that single-phase alternating current circuit to be regulated at the machine. By overloading these two circuits 15%, the capacity of the generator is about the same as for motor circuits with a power factor of 0.8. The units in a station can then be alike, and it does not interfere with paralleling, or running motors and lights from the same machine if necessary. Another method used in Switzerland but only with two-phase generators, is to construct a sort of double machine, the two halves of which may be mechanically displaced relatively to each other to generate two-phase currents for power purposes, or they may be connected in line with each other to generate single-phase currents for lighting.

MOTORS.

Among the various types of motors, the most interesting was the three-phase induction or Tesla type, which seems now to have demonstrated its superiority over all the others except perhaps the continuous current motor, upon whose field it is however encroaching very decidedly, with the present prospect of becoming its equal in importance. The largest company in Germany and perhaps in the world, estimates that its sale of three-phase induction motors will before long exceed that of its continuous current motors. Its very large factory, including even the rolling mill, is equipped with these induction motors mostly direct connected. There is a single textile factory in Switzerland in which 500 of these motors are used for direct driving. The induction motors, almost exclusively of the three-phase and not two-phase type, are being introduced very largely now, especially in Germany and Switzerland.

A nearly uniform type seems to have been adopted by most of the makers. In this, the primary circuit is the stationary one, and is distributed over the surface like a drum winding, as distinguished from the coils used in the earlier forms of Tesla. It is this distributed winding which is the chief improvement that has made them such a success; it seems to have been first introduced by Dobrowolsky in Berlin. The larger ones are almost always started with a resistance in the secondary external to the motor; in some cases a short-circuiting device is provided on the rotor for use after starting, so that the brushes may be raised while running, to prevent wear. It will be noticed that in some respects this nearly universal practice abroad differs from that in this country where even very large motors up to 800 HP. if not more, are made without any brushes, being started with a transformed current at lower voltage; others are made with the starting resistances on the rotor itself, which also dispenses with brushes.

Among the few other devices exhibited for starting such motors, the object of all of which is the avoidance of slide rings, may be mentioned the ingenious one of Fischer-Hinnen, who uses an inductive resistance of very low ohmic resistance, in parallel with a non-inductive one of high ohmic resistance; together they act like a high ohmic resistance when the motor starts, owing to the high frequency of the secondary currents, and diminish automatically as the motor increases in speed, because the frequency of the secondary then diminishes; they are permanently connected to the rotor. In the Deri motor the number of poles is changed by a switch in the primary, and the resistances are permanently connected between points of the secondary which have a difference of potential for one number of poles, but are of the same potential for a different number of poles; they are therefore either in or out of circuit and admit of no gradation, which is a disadvantage. Boucherot uses practically a double motor, the field of one of which may be mechanically turned through a certain angle for starting; the two secondaries are permanently short-circuited in series with each other, but have resistances connected between the coils through which the secondary current is forced to pass when one of the fields is displaced, but only then; it seems like a rather complicated device as compared with the simpler slide rings which it replaces.

For the A. E. G. induction motors, Dobrowolsky claims that they will stand a 200% overload, have a power factor of over 0.9 and still give the normal output for two-thirds the normal voltage.

Induction motors are built on the continent for high voltages up to 6,000 and I believe even 10,000, thus saving the transformers for all but higher voltages than these.

As to single-phase induction or non-synchronous motors, it looked as though most of their makers thought it best not to exhibit them, or to evade questions asked about them. Among the exceptions may be mentioned the Brown and the Oerlikon motors, both of which start with an auxiliary winding. Brown, who constructs them up to 100 HP., states that they start with ¼ to ⅓ full load torque at about normal full load current. He has even made them for starting with full load torque at about double normal current. The air gaps are very small, from 1 to 1½ mm. A cheap liquid condenser made of iron plates in soda solution, is used for producing the artificial starting phase. The Oerlikon motors are claimed to start with ¼ normal torque requiring 80% normal current, and to stand an overload of 50%. An impedance coil is used for starting.

A very interesting installation of single-phase motors, and quite a unique one, exists in Frankfort-on-Maine, Germany, where about 500 such motors, mostly by Brown, are connected to the large single-phase alternating current plant, the motor load of which has leveled the load curve very decidedly. They vary in size up to 100 HP. and are used even for elevator work. They appear to be satisfactory to the users, even though they must always be started unloaded. This is probably the largest motor plant of its kind and shows what can be done even with single-phase motors.

One of the applications of three-phase induction motors which is of special interest, and which seems to have a promising future, is to traction. This three-phase traction system, which is scarcely known in this country, is in regular and apparently very successful use on a number of lines in Switzerland, where it is being introduced by such well-known constructors as Brown, Boveri & Co., and the Oerlikon Co. A few of these roads were visited by the writer and as far as could be learned they were running very satisfactorily. The double trolley wire, which is essential, and which has often been urged as being such a serious objection, does not seem to give any trouble at all; each locomotive or car had even two contacts with each wire. Many of the alleged objections are overcome by the use of the contact bar instead of the trolley wheel, which completely avoids any jumping off of the pole, and greatly simplifies the overhead wiring at the switches, which is in fact not complicated at all. The motors are started with resistances in the secondary as usual. There is no complicated controller, as the two motors are always in parallel. The trains start well and without difficulty, and it seems, without any very abnormal current. The chief objection to the system seems to be that the running speed is always the same, in which respect it is like a cable road; it is therefore not possible to make up lost time except on a down hill coast, while on steep up grades there is a considerable demand for power as the speed is always the same maximum. No system of efficient speed regulation is used, presumably because none has been found to be satisfactory. This seems to be the real and serious objection to the use of the system in this country, where high speed seems to be an essential requirement. One of the freight locomotives was provided with a purely mechanical device for halving the normal speed, but no other information could be obtained than that it was then in the repair shop.

On that bold enterprise, the Jungfrau railway, which will ascend one of the highest snow peaks in Europe, a very ingenious and apparently novel device is used on one of the Oerlikon three-phase locomotives, in order to enable a train to descend to a habitable region even if connection with the power house is broken or if something should happen to the trolley wires or poles. Ordinarily in descending, the induction motors act as generators, sending their current back into the line, which therefore must be intact. The device referred to, consists of a small direct current generator driven by the descending locomotive, the current from which is led into one branch of the star or Y-connected primary and out at the other two ends in multiple; this excites the motor and it then generates alternating currents in the secondary which are dissipated in the resistances used for starting; it thus operates as an electric brake without being in contact with the line.

While three-phase traction in its present state would probably not be practicable here for cities, there seems to be a field for it on long distance interurban lines with few stops, as it is much cheaper. The estimates for the Jungfrau railway showed that the first cost would have been 50% greater if the continuous current had been used on the locomotives, as is done in this country.

Another interesting characteristic difference between American and continental practice, is that here synchronous converters combined with transformers are more generally used for transforming high voltage three-phase currents into low voltage direct currents, while on the continent dynamos driven by high voltage induction or synchronous motors are the rule. Although the favorable features of each are well understood, the reasons given by such a successful constructor as Brown for preferring motor-generators, may nevertheless be of interest here. He states that they can be regulated with ease and precision; no transformers; both parts can be better designed without making concessions; no hunting; ease in starting; no depolarization possible; secondary voltage absolutely independent of the primary. He admits that the synchronous converter is cheaper and more efficient, but claims that the differences are but slight; he has obtained 90% combined efficiency for a 250 K-W. motor-generator set.

It was of some interest to note the almost complete disappearance of the Gramme ring armature among generators and motors, and the use of multipolar fields for smaller sizes than formerly, especially with motors. The Dobrowolsky system, hardly known here, of supplying three wire circuits from a single generator, by connecting the neutral through induction coils and slide rings to two opposite parts of the armature winding, seems to be meeting with favor on the continent.

ELECTRIC RAILWAYS.

In electric railroading there seemed to be comparatively little of special interest to Americans, besides the three-phase motor system and the contact bar, already referred to, both of which deserve more attention here than they are getting. The new Metropolitan underground electric road quite recently opened in Paris, is apparently an excellently constructed but wretchedly managed road. American management would diminish the total time of transit and increase the profits greatly. It is an improvement over the new underground road in London in that motor cars are used instead of locomotives, but being directly under the street instead of very deep, as in London, the excellent device of a descending and an ascending grade between stations, to aid acceleration and stopping, cannot be taken advantage of. Both of these roads use American electrical machinery.

The two new electrically operated extensions of several steam railroads into the central parts of Paris; the new and much needed electric railroad to Versailles; and the new conduit road in Paris, are all of interest. A surface contact line and one using accumulators, are also being tried in Paris.

In the exhibition itself may be mentioned the two miles of moving platform which differed from the one in Chicago in that the motors were stationary while the rails moved. The third rail electric railroad paralleling it but running in the opposite direction, was virtually an American exhibit and was managed more like American roads, making a refreshing contrast to the wretchedly managed tramways and omnibuses in the city. Both the platform and this railway were fed from two 800-HP. induction motor-generator sets made in this country, the induction motor, started by its mate, being one of the largest ever made. The conduit road which was shown, was also virtually one of those developed in this country. A short section of the "suspended" railway was exhibited, but whether this struggle for recognition was successful seems questionable. Another curious departure shown in operation was the trolley automotor, a system of running electrically driven vehicles on ordinary roads, but taking current from an overhead trolley wire. The novel feature was that the small contact carriage running on the two wires, was geared electrically to the motors by means of a local three-phase current, so that it tended to travel slightly faster, thereby always leading and keeping the connecting cable taut. A field for it might exist where omnibuses are now used.

ELECTRIC LIGHTING.

In electric lighting, one of the most interesting features was the debut of the Nernst lamp. After long and tedious labors on the part of the General Electric Co., of Berlin, the interesting laboratory experiment of Nernst, that a filament of a non-conductor like magnesia becomes a conductor after it is heated—has been developed into a form of high efficiency incandescent lamp, which is now claimed to be ready for the market; but although several hundred were burning there daily it was not possible to buy one. It resembles the usual incandescent lamp except that the bulb is open; the filament is somewhat thicker and much shorter than that of a carbon lamp; the light is very much whiter and more brilliant. It can be lighted with a match, alcohol torch or automatically by a platinum wire preheater with a magnetic interrupter. Either alternating or continuous currents can be used but the filament must be exposed to the air. The lamps are made for 25, 50 and 100 c. p. at 220 volts, and therefore do not yet compete directly with the usual 16-c. p. lamp. The efficiency is said to be 1.5 watts per candle, or about twice as good as the present carbon lamp of the same voltage. The filament is said to be made of magnesia mixed with the rare earths like zircon, thorium, etc. The life is claimed to be very satisfactory, though no figures could be obtained, but the perishable parts valued at only 25% of the probable cost of the lamp, can easily be replaced, the bulb being open.

The material of which the filament is made has a rapidly falling temperature coefficient, much worse than carbon, which would make it extremely sensitive to changes in voltage. This is overcome by a very ingenious method to which the present success of the lamp is due; it consists in placing a very fine iron wire in series with the filament, the wire being so proportioned that it is heated by the normal current to that temperature (about 450 to 500° C) at which it has a very rapidly rising temperature coefficient; the resulting characteristic of the two in series is therefore a rising one. This fine wire consumes

about 10% of the voltage. The price of the lamp, it is thought, may be about 50 cts.

Among the novelties in arc lamps which attracted some attention during the few days it was on exhibition, was the Bremer lamp in which the carbons contain certain salts, like those of magnesia, together with fluor calcium, that deposits a white oxide on surrounding bodies which acts both as a Nernst conductor and a white reflector, the carbons being inclined like the letter V. A reliable German authority found the efficiency to be 0.13 watts per hemispherical candle power. The light is said to be steady and bright but soft.

The only enclosed arc lamps exhibited were from this country, directly or indirectly. These lamps, which are so largely adopted here, are scarcely known on the continent, and in France at least, it seems that they are not even wanted, on the ground that the light is too blue and unsteady, and the efficiency too low. As manual labor is much cheaper there than here, and arc lamps are not used nearly as much, the chief advantage of this lamp is not appreciated, at least not yet. The arc lights there are, as a rule, much steadier, and are almost universally connected to constant potential circuits, our series system being almost unknown. The general type of regulating mechanism which is in favor, is that in which the coil applies a brake to an escapement wheel which tends to revolve by the weight of the descending carbon; the regulation is therefore very sensitive and gradual. Cored carbons of a fine quality are moreover almost universally used. Generally only two lamps are in series across the usual 110-volt mains, but in some cases as many as three are connected with an increase in light efficiency; in such cases the lamps are of the differential type in which the regulating mechanism is actuated not only by a shunt coil but also by one in series.

TRANSMISSION APPARATUS.

The relatively large number of exhibits of switchboard switches for breaking currents of very high voltage, indicates the rapid introduction of high tension currents. In many of them the well-known double horn is used for extinguishing the arc, which is an indication of the effectiveness of this simple device. A novel departure in switchboards, especially for dangerously high voltage machines, consisted in placing all the switching apparatus belonging to one machine, on or under a post or pedestal near the machine itself, and so that the attendant faces the machine. The actual switches are under the floor where they are out of the way and easily accessible from a pit below, only the levers, hand wheels and instruments being on the pedestal; the attendant is thereby protected from all the possible danger. It is the standard practice of the Oerlikon Co.

Among the cable exhibits there were three for underground work in which multiple cored cables were subjected to 25,000 and 30,000 volts alternating, the insulation in one of these being impregnated paper without any rubber.

A German maker of aluminum goods showed that this metal can be welded without solder or flux by simply heating it to a certain definite temperature at which it softens. The use of aluminum line wires makes this simple method of interest to electrical engineers.

In telegraphy the exhibit which seemed to attract most attention was the very ingenious printing telegraph system of Professor Henry A. Rowland, of Baltimore. The sender merely presses lettered keys like on a typewriter, and at the other end the message is received in print on a sheet of paper ready for delivery, without requiring any operator. An alternating current of constant frequency is passed over the single line and operates synchronous motors, by means of which the necessary synchronism at the two stations is obtained. The different characters are transmitted by the suppressing of various combinations of the half waves of the current. At the receiver end those waves are received in a large number of relays, various combinations of which operate a few electro-magnets for printing the characters and moving the paper laterally and lengthwise. The typewheel revolves continously and the paper directly beneath it is struck from below at the exact moment when the desired letter is over the paper. Four messages are sent at the same time in one direction, the line being loaned to each operator in succession for short recurring periods. This is then also duplexed, making eight messages simultaneously over one wire, each, it is claimed, at a speed of 45 words per minute. It does not seem to be used commercially yet, and whether it will be equal to or better than the printing telegraph system which has been in satisfactory commercial use between New York and Chicago for some time, devised by one of our members, can be determined only by equally severe tests.

The telegraphone was one of the very few entirely novel inventions of promising value exhibited. This extremely ingenious and very interesting invention of Poulsen, a Dane, may be said to be a magnetic phonograph in which a long hardened steel wire is passed rapidly near the magnet of a telephone receiver, the magnetic variations of which are thereby recorded on it in the form of parmanent magnetism. By then passing this wire under small pieces of iron attached to a diaphragm, the same sounds are reproduced. I had the pleasure of hearing such a reproduction and can vouch for the statement that it is much clearer than from an ordinary phonograph, as there is an entire absence of that objectionable scratching noise, there being no mechanical contact at all. Its suggested applications are numerous, including duplex and multiple telephony.

ELECTRO-CHEMICAL EXHIBITS.

A very large ozone apparatus was shown in operation, for sterilizing 200,000 cu. met. of water per 24 hours by the Marmier and Abraham process, but a confirmation of the claims is very desirable.

In accumulators there was shown a general tendency, though not a universal one, to use Plante positives and Faure negatives, a combination which seems to have given the least trouble. Accumulators are now the rule and not the exception in continental lighting and traction stations. Now that the fundamental patents have run out in this country, we ought to use them more freely here. As an electrical flywheel and a comforting reserve in a central station, the accumulator has no equal.

A very interesting and promising method was shown in operation by its inventor, Rieder, for electrolytically engraving deep, hard steel dies, such as are used for pressing the reliefs on coins and for embossed work in general. A porous negative of plaster of Paris, saturated with chloride of ammonium, is lightly pressed against the steel blank and the metal is dissolved off electrolytically by a current, wherever the negative touches it. The cost is said to be only half that of the usual hand method.

AMERICAN AND FOREIGN MANUFACTURING PROCESSES.

A characteristic difference between American and foreign practice in manufacturing, as for instance such goods as dynamos and motors, is that here the manufacturer establishes certain well studied and well developed standard types and sizes of machines once for all, and then reproduces them in large numbers, making the parts interchangeable. The foreign manufacturer, on the other hand, constructs each machine according to the detailed specifications of the one ordering it. He argues that if he should make bids with standard sizes in stock, the purchaser would accept the bid of some one else who would construct the machines exactly according to the specifications. As a matter of fact, however, it was noticeable that those companies which have adopted the American method, were as a rule the most successful.

Another difference is that here the manufacturer as a rule devotes his whole effort to a single class of goods, and makes these in large quantities, while abroad he attempts to make a large range of widely different kinds of articles; this seems practical only when each branch is a large business in itself.

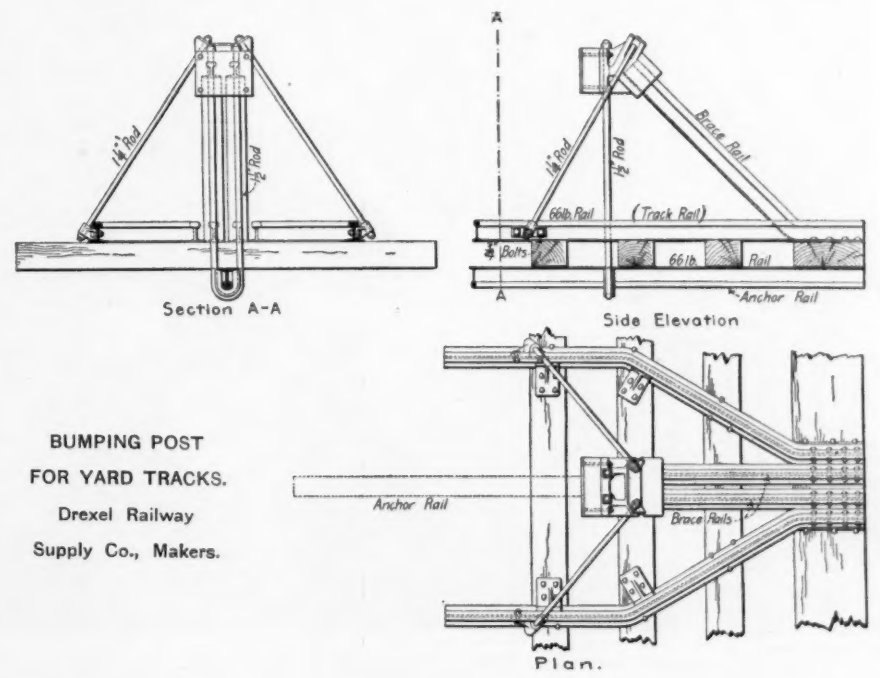
Still another difference is in the fine external finishing of even those parts of an apparatus which are concealed. Their argument is that all parts of a well made apparatus ought to look well, and that it will then be handled with greater care and respect. Here we would consider it a useless expenditure of money to polish all the concealed mechanism of arc lamps, for instance. The foreigner, however, is apt to judge our goods from his standpoint, at least until he can be convinced of their advantages.

While we may have just pride in feeling that some branches of electrical engineering are better developed here than in other countries, and that our method of manufacturing certain classes of goods is superior, yet we should not forget that others who have worked equally hard in other countries often reach conclusions differing from ours, and which may well be worth our while to consider. Although our typically American practice of manufacturing standard types in large quantities and with interchangeable parts, undoubtedly has great advantages, yet that is the very method which tends to retard development in those types, as it makes one hesitate, perhaps too long sometimes, to make improvements. On the other hand the typically European method of building almost every machine differently, gives an excellent opportunity for developing them, but precludes wholesale manufacture at reduced cost. Such international meetings therefore can hardly fail to be of benefit to all who take part, as they enable one to find, through personal observation and personal intercourse, that which is the best the world over, just as our home meetings bring before us the best in our own country. If we want to manufacture the best there is, especially if we want the foreigner to buy it from us, we should have international intercourse.

BUMPING POST FOR YARD TRACKS.

The subject of bumping posts aroused quite a lively discussion at the recent annual meeting of the Association of Railway Superintendents of Bridges and Buildings. Two particular points brought out were (1) that the spring capacity of bumpers fitted with springs is usually insufficient for requirements, and (2) that under certain conditions it may be well to dispense with the post altogether, the superintendent issuing orders to the effect that trainmen who get cars off the end of the track will be summarily dealt with.

The bumping post which is illustrated in the accompanying cut (and which was one of the exhibits at the meeting above referred to), consists of a heavy bumper head carried by two inclined brace rails, and tied to the track rails by 1¼-in. guy rods. A vertical U-rod also anchors the head to a rail laid under the ties and extending so far ahead of the bumper that the weight of the car comes upon this rail before the coupler strikes the bumper head. Beyond the anchor rod the track rails are inclined inwards, and the brace rails fit between their ends, all the rails being riveted to a base plate. This device is known as the Gibraltar bumper, and is in use on the Boston & Maine, Baltimore & Ohio, Penpsylvania Lines West of Pittsburg, Chicago, Rock Island & Pacific and other important railway lines. It is being introduced by the Drexel Railway Supply Co., Fisher Building, Chicago, Ill., and we are indebted to that company for the blue prints from which the accompanying cut has been made.



BUMPING POST FOR YARD TRACKS. Drexel Railway Supply Co., Makers.

THE CAUVERY POWER TRANSMISSION SCHEME, INDIA.*

The project for the utilization of the power available in the Falls of the Cauvery for the generation and transmission of electrical energy to the gold fields of the Kolar district of Mysore, has naturally attracted considerable attention in the engineering world. The conception of the project is due to Major A. J. de Lotbiniere, R. E. The Government of Mysore, with their professional adviser, Colonel Robertson, Chief of the State Public Works Department, are to be congratulated upon the far-seeing policy which has led them to lose no time in putting the scheme into actual execution. To the State of Mysore will belong the credit due to being the first in the field in India to bring the potential energy of its rivers to the assistance of industry.

The Cauvery River rises in the Western Ghauts, flows in a southeasterly direction through Mysore State and Madras, discharging in the Bay of Bengal, after a course of some 475 miles. The Falls of the Cauvery at which the generating station will be situated are at Sivasumadarum Island, some 50 miles below Seringapatam, of famous memory, and a distance of about 93 miles across country from Kolar, the center of the Mysore gold mining industry, where the power is to be applied.

The discharge required to generate sufficient power at the Falls to transmit and deliver 4,000 HP. at the Kolar gold fields has been found to be 181 cu. ft. per second, and observations have shown that even in the dryest month of the dryest season on record the quantity required is easily available. The actual horse-power generated at the Falls power station will be 5,970, and an allowance of 33% has been made for loss during transit.

It is proposed to erect a low dam at W X which will serve to divert the dry weather flow of the river into the western branch. Across this western branch at A, a low anicut, or dam will be erected. This dam will serve as a barrier during the dry-weather only, and will not form an obstacle to the passage of flood water. Two channels will be excavated from the left flank of the anicut, sufficient to carry 220 cu. ft. per second each. It has been considered advisable to build two channels once and for all, as the works will be enlarged in all probability soon after completion.

These channels, which will be in excavation throughout their length of 3⅛ miles, terminate at the point B, which is a high bluff overlooking the river. From the end of the channel three steel pipes 36 ins. in diameter will carry the supply of water under pressure to the generating station, which will be situated on the margin of the river 6 ft. above highest flood level and 410 below the end of the channel.

The generators will consist of six complete units of 1,000 HP. each; each unit comprising a water wheel and generator on a horizontal shaft. The generators will work at 2,200 volts, and step-up transformers will be employed to raise the voltage from 2,200 to 30,000. At the receiving end of the line, step-down transformers will reduce this voltage to 4,000 for distribution purposes, and at each mine, secondary transformers will be employed to still further reduce the voltage to between 150 and 200.

The transmission line, 90 miles in length, will be in duplicate, each set of poles carrying three wires. As a rule both lines will be used, each line taking half the current, but in the event of one failing, the remaining line will be sufficient to carry the whole current. In order to reduce the line loss to a minimum, change-over stations will be provided at 30-mile intervals. These stations will enable sections of the line to be thrown out of operation for repair at any time, without interfering with the remaining portions of the same line. For instance, if an insulator failed at mile 35 out, on No. 1 line, the section in which this insulator happened to be would be cut out, and the ends of sections Nos. 1 and 3 of line No. 1 would be connected with No. 2 line at both ends. The current carried by No. 1 line would then travel over No. 1 for 30 miles, cross over to No. 2 from the 30th to 60th mile, and then back to No. 1 from the 60th mile to the end. The result would be increased line loss due to ½ of No. 1 line being out of operation only. Without change-over stations, if one line were cut out for repairs, and the whole current carried on the other, the line loss would be doubled. Ordinarily, each line will carry half the current with a loss of a little over 13%.

FALLS OF THE CAUVERY RIVER, MYSORE, INDIA.

The contractors for the generating plant and transmission lines are the General Electric Co., of Schenectady, U. S. A. The turbines (modified Pelton wheels) are to be supplied by Messrs. Escher Wyss & Co., of Zurich, and it is provided in the agreement with the contractors that the water-wheels for driving the generators shall each deliver to the corresponding generator shaft under normal conditions 1,015 brake HP. and a maximum of 1,260 brake HP. The regulation of the water-wheels is specified as follows: If 25% of the full normal load be thrown off or on instantaneously, the increase or decrease in speed is not to exceed 3% of normal speed. If 50% of full normal load be thrown off or on instantaneously, the increase or decrease in speed is not to be greater than 5% of the normal speed. If the full normal load be thrown off or on instantaneously the increase or decrease in speed is not to exceed 10% of the normal speed. Furthermore, the governors must not race under sudden variations of load, and in steady or gradually changing loads they must not allow a variation in speed of more than 1% from the normal.

A number of leading electrical manufacturing firms sent in their proposals for the scheme, that of the General Electric Co., as we have already stated, being accepted. In their scheme the generator proposed is of the stationary slotted armature type with revolving field, either on one bed-plate with the turbine or separate. The armature will be tested for one minute with an alternating pressure of 5,000 volts, the working pressure being 2,200 volts. The efficiency claimed is high, namely, 96% at full load. The armature is made to slide off parallel to the shaft for repair.

The voltage proposed for the exciters is only 80 volts. This low voltage is proposed in order to enable a strip winding to be used on the generator field-magnets, giving an advantage in reducing the bulk of the field coils and also reducing their temperature, both on account of the reduced bulk and of one edge of the strip being exposed to the air. Moderate-sized single-phase units are proposed, and either air-blast or water-cooled oil transformers are specified.

The lightning arresters proposed consist of a number of metallic balls with air gaps in between, and put in series with a graphite resistance. They depend for their action in extinguishing the arc formed, on the cooling effect of the masses of metal combined with the reduced current due to the resistance. They are said to have been used successfully in a large number of installations. The wire specified is No. 0 B. and S. gage having a cross-section of about 0.829 sq. ins. The total weight will be about 410 tons.

The General Electric Co.'s contract price for the entire electrical equipment amount to £140,941 ($685,000).

The scheme is at present at the following stage. The sanction of the Government of India has been obtained. An arrangement has been entered into by the Government of Mysore with the Government of Madras for the supply of water in the Cauvery River. Tenders for the execution of the necessary works in India have been accepted, and the collection of materials and the excavation of the channels begun. Agreements have been entered into for the supply of the generating and transmission plant, and with the various mining companies for the supply of electrical power. The tenders for the plant stipulated that the whole should be fitted up and running in less than twenty months from the date of acceptance (15th July, 1900). The tenders already accepted only provide for the generation and transmission of the power to a central station in the Gold Mines district, and arrangements are now in progress for accepting tenders for the distribution of the power from the central station to the various machines on the mines.

The foregoing notes give in brief outline the project and general position of one of the most enterprising and interesting engineering shemes in the annals of the British rule in India. The only point for regret to us is, that practically the whole of the plant will be of foreign manufacture; but with many American engines on our railway lines, American rails to run them on, and the general enterprise of America in engineering and its allied trades, we must be content to acknowledge that the British manufacturer is quite unable to retain his old monopoly in the wide marches of the Empire.

*From the "Indian and Eastern Engineer" for September.

NOTES FROM WATER-WORKS REPORTS.

BOSTON AND VICINITY.—Among the many interesting things in the last report of the Metropolitan Water Commission is an outline of the swamp drainage work done during the year. The object of this work is to divert water from the uplands to the reservoirs, without having it come in contact with the vegetable matter in the swamps, such contact allowing the water to take up color, and also to take up vegetable organic matter which may serve as food to organic life in the reservoirs. The swamps, after being cut off by drainage ditches, "become moderately dry, as they receive little water except from the fall of rain directly upon them." In a swamp tributary to the open channel section of the Wachusett reservoir, 45,250 ft. of ditches were cut. This swamp was one of the largest to be dealt with, having an area of 460 acres and a drainage area of 2.9 sq. miles. Mr. F. P. Stearns, M. Am. Soc. C. E., is chief engineer of the board.

In the annual report of Mr. A. P. Martin, Water Commissioner of Boston, there is a continuation of the studies of electrolysis which have been carried out in that city for a number of years past by Stone & Webster, of Boston. The readings of differences in voltage between water mains and street car tracks in 1898, and in both the spring and fall of 1899, are given in detail by streets. The conclusions of the engineers were that there was but little electrolytic action apparent in 1899. Mr. Wm. Jackson, M. Am. Soc. C. E., is city engineer of Boston.

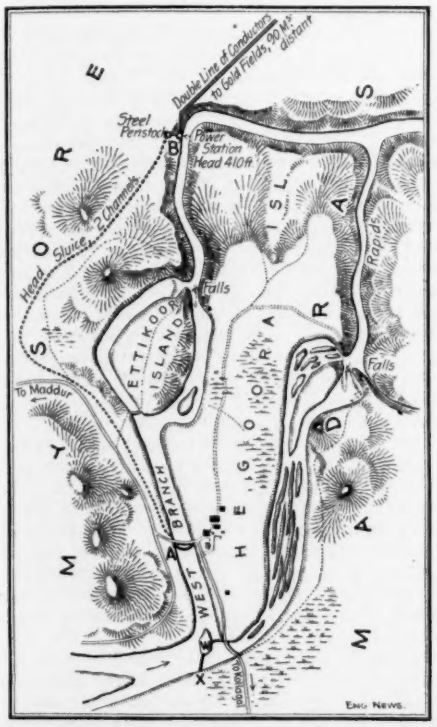
BROOKLINE, MASS.—Meters are more popular here than in many other places, more than half the revenue in 1899-00 having been from meter rates, although nearly all meters are set at the request of consumers. Mr. F. F. Forbes is superintendent of the water-works.

FALL RIVER, MASS.—With an average daily

water consumption of only 35 gallons per capita, and 6,363 out of 6,783 taps metered, the water department can account for only 75.57% of the total quantity of water pumped. The few unmetered taps, it is estimated, draw three times as much water as the metered and 5% is allowed for under-registration of the meters. All the public buildings are metered. Of the 75.57% of water accounted for, 60.24% (of the total pumpage) was consumed by purchasers and 15.33% was used for public purposes, the latter including a number of estimates. Mr. Patrick Kieran is superintendent of the water-works.

LYNN, MASS.—This is one of the very few cities which has a systematic microscopical examination of its water supply made. The report of the water board for 1899 contains tables giving the results of one such examination each month, but weekly examinations were made. There are no comments on the tables. The late Mr. John C. Haskell was superintendent of the water-works during the year covered by the report.

ALBANY, N. Y.—The report of the water commissioners for 1899 contains a long and fully-illustrated description of the water purification



Map of Cauvery River, India, Showing Location of Water-Power Canal.

plant, written by Mr. Allen Hazen, M. Am. Soc. C. E., Chief Engineer of the improvement. The report states that all the laboratory work in connection with the plant is done under a contract with the Bender Hygienic Laboratory, Mr. Leonard M. Wachter being the chemist in charge. A review of the operations of the filters during the year is given by Mr. Geo. I. Bailey, M. Am. Soc. C. E., Superintendent. The purification works were described in detail in Engineering News for Feb. 10 and Oct. 20, 1898, and Jan. 11, 1900, and their operation to July 1, 1900, was reviewed by Mr. Bailey in our issue of Aug. 9, 1900. This review was followed by two letters, in our issues of Aug. 30 and Sept. 6, 1900, on the relative cost of water purification at Albany and at Lawrence, Mass.

ATLANTIC CITY, N. J.—A simple form of standard meter box is shown by a view in the report of the water commissioners for 1898-9. The interior dimensions are 20 × 20 ins., × 24 ins. high. The walls and cover are of flagging stone, the walls being dowelled together, roughly. Mr. W. C. Hawley, Assoc. M. Am. Soc. C. E., is superintendent of these works.

PHILADELPHIA, PA.—The daily per capita water consumption is placed at 199.6 gallons in the last report of the bureau of water, but this is too low, since the census of June 30, 1900, gives the population as only 1,294,000, against the estimate of 1,453,000 used in the report. The total gain in population for the last decade was 247,000, or an average of nearly 25,000 a year. Presumably the last year of the decade had its proportionate share of the total increase, so the average population for 1899 may be placed at 1,270,000, giving an average daily consumption of 229 gallons per capita, instead of 199.6 gallons. The consumption in 1890, based on the U. S. census for that year, was 132 gallons, so that the increase in nine years has been nearly 100 gallons per capita per day, the increase alone being nearly equal to the per capita consumption in Greater New York. Mr. F. L. Hand was acting chief of the bureau after the resignation of Mr. John C. Trautwine, Jr., Assoc. Am. Soc. C. E., on Nov. 15, 1899.

READING, PA.—The indifference of citizens to questions of vital importance is illustrated by the vote on improving a portion of the water supply of Reading by filtration. Of a total vote of 26,365 for candidates for office only 6,608 voted on the water question, and 4,572 of those voted against the improvement. The filtration works were proposed to rectify the occasional bad taste and odor in the Antietam Lake supply, due to the growth of minute organisms, chiefly anabaena.

WASHINGTON, D. C.—To meet the demands of people whose purses do not permit them to escape from the Potomac River water, no matter how muddy or warm it may be, there were 101 shallow and 36 drilled public wells in use in Washington during the year 1898-9. Most of the shallow wells are located beneath the sidewalks, near the curb. They range from 11 to 60 ft. in depth, 75% being less than 30 ft. deep. The average depth of water is about 4.5 ft. Chemical analyses of water from these wells, made by Mr. A. W. Dow, Inspector of Asphalts and Cements, shows many of them to be badly polluted, while each of them is liable to be contaminated at any time. Ammonias are almost invariably low in these well waters, due to nitrification, as the water filters through the soil. In view of this fact, and of the desirability of making as frequent analyses as possible, ammonia determinations are made only in special cases, attention being concentrated on the more rapid tests for nitrites, nitrates, chlorine and oxygen consumed. The analyses show great fluctuations in the characteristics of the well waters, due to two sources: (1) Drainage from defective box privies, house sewer pipes and the surface of the ground, which increases the chlorine and nitrates; and (2) leakage from sewers, which, owing to the great dilution of the sewage with Potomac water, often lowers the chlorine and nitrates in the water that feeds the wells. Most of the shallow wells are not popular, owing to the depth from which the water must be raised, their infrequent use and the coloring of the water by iron, due to the water standing in the well casings.

OBERLIN, O.—Beginning with May 1, 1900, all residences and boarding-houses having water-closets were to be supplied with water by meter measurement, only. Early in 1900, 85% of such buildings were metered, and every meter, in these or in other buildings, had been set at the request of the water taker. Of 596 services in use at the close of the year, 305 were metered. In all but two cases, the introduction of meters cut down the bills of the consumers. The consumption of water in 1899-00 was 22 gallons per inhabitant, 38 per consumer (population supplied), and 178 per tap. Of the 305 meters, 300 were on domestic services. As the village treats all its sewage on land, and has the separate system of sewers, the advantages of keeping down water consumption and waste are doubly evident. Mr. W. B. Gerrish is city engineer and superintendent of water-works.

DETROIT, MICH.—Hourly water pressure gage readings have been made at 24 different points in the city, besides the pumping station, during the six years 1894-9, inclusive, making a total of 8,760 readings a year at each gage. A table showing the results of these gagings is included in the last report of Mr. C. W. Hubbell, Jun. Am. Soc. C. E., Civil Engineer to the water commissioners. The table shows the elevation of each gage, the static pressure corresponding to the difference in elevation between the pumping station gage and the various outside gages; the average pressure, in pounds, shown on each gage for the whole of each year, and the maximum and minimum pressures, omitting extremes due to accidents; the average frictional loss, in pounds, at each gage, by years; and the total and percentage of increase in friction during 1899. The latter ranged from 0.76 lbs. (leaving out one case of decreased friction) to 2.34 lbs., actual, while the percentages ranged from 15 to 75%. The table is a good example of profitable systematic study of the operations of a water-works system.

GRAND RAPIDS, MICH.—Daily turbidity readings of the river water were made during the past year, a plan which is being adopted by a number of works and deserves to be put in practice wherever cities are troubled with turbid water. The method used is not stated, but probably the platinum wire gage was used. Mr. Geo. M. Ames, Assoc. M. Am. Soc. C. E., is city engineer, and Mr. F. A. Twamley is water registrar.

ELGIN, ILL.—The gross injustice of compelling private water consumers to bear the whole expense of a water-works system is forcibly illustrated by some statements in the last report of the water commissioners of Elgin. Of some 8,000 taxpayers, 2,000 are bearing the whole expense of the works, including water used for fire protection and other public purposes. Mr. R. R. Parkin is superintendent of these works.

ST. LOUIS, MO.—Of a total of 616 miles of water mains, this city had, on April 1, 1900, 11.4 miles of 3-in., 1.8 of 4-in., 369.6 of 6-in., 10.9 of 8-in., 9.5 of 10-in., 106.6 of 12-in., 10.1 of 15-in., 53.4 of 20-in., 22.3 of 30-in., 20 of 36-in., and 0.2 miles of 48-in. pipe. About 15% of the total mileage was 20 ins. or more in diameter. Mr. Edw. Flad, M. Am. Soc. C. E., is water commissioner.

A DANUBE-ADRIATIC CANAL CONCESSION has been secured by Herr Wagenfahrer, of Vienna. It is proposed to build a canal connecting the Danube, a little below Vienna, with the Adriatic, at Trieste, a distance of about 319 miles. The "Bolletine della Fianze," which publishes this news, gives no further particulars, but estimates the cost at 600,000,000 francs, or $120,000,000.

ROUND VS. FLAT MINING CABLES are discussed in the "Oesterrischische Leitschrift fur Berg und Huttenwesen," for May 12, 1900. A table is given of the experience with 6,073 hauling cables used between 1872 and 1898. These cables include round cables of steel and iron wire, flat cables in steel and iron wire, aloe fiber, etc. In 1872 19.30% of cables changed had been broken in service; in 1898 this rate was only 0.54%. This latter result is chiefly due to the rejection of iron for this purpose and the employment of a good grade of steel. The tables show that the life of a flat cable never exceeded 800 days, while round steel cables have lasted 1,200, 1,400, 1,600 and more days. The useful effect of the round cable is also superior to the flat cable; round cable records show a useful effect of 300, 400 and even 500 thousand millions of kilogrammes, while the flat cables never show more than 75 thousand millions of kilogrammes. The writer believes that in a very few years round steel cables will entirely supplant all flat steel or fiber cables in the mining districts of Dortmund and Breslau.

ALUMINUM AT THE PARIS EXPOSITION is treated in an article in the "Moniteur Scientifique Quesneville" for August. There are two French companies now making aluminum—the Societe Electro-Metallurgique Francaise and the Societe des Produits Chimiques d'Alais et de la Camarque. The total power utilized has declined from 13,000 to 6,500 HP. In Switzerland the Societe de l'Aluminum utilizes the falls at Schafhousen and obtains 4,500 HP. In Germany the Societe de Greisheim has commenced the manufacture of magnesium at Hemebrigen, and is credited with intending to make aluminum. The British Aluminum Co. is the only English establishment making this metal. In the United States there are two companies; one utilizing 2,500 HP., furnished by natural gas; the other, 1,900 HP., obtained from Niagara Falls. The figures for the total production of aluminum vary from 6,000 to 13,000 tons annually, according to different authorities, but since 1892, when aluminum contained 5% of impurities, the processes have advanced until the two French companies named are said to furnish it 99.5% fine. The price has fallen from 56 francs in 1889 to 3.50 francs per kilo., or 31.8 cts. per pound. One French company proposes to furnish the metal 90% fine at about 18 cts. per pound.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

When any reform which commends itself to a large body of people is under discussion, the opinion is often heard that the National Government ought to take the matter up. It matters not what the subject may be, from the liquor traffic to the merchant marine, there are plenty of well-meaning souls who at once clamor that the United States ought to interfere and set matters right.

Last week, at Chicago, a national "good roads" convention was held; and the opinion was freely expressed that the Government ought to make large appropriations for the construction of good roads. The convention, as a whole, we are glad to say, did not advocate so radical a departure from the present governmental system, but it did adopt a resolution favoring an increase to $150,000 in the appropriation for the Road Inquiry Bureau of the Department of Agriculture.

The idea that the National Government should undertake the improvement of common roads is based on the too common fallacy that the nation, in some way or other, has ampler means at its command than the States of which it is composed or the people which inhabit them. It is time that this fallacy was set right. All the money that either Nation or State or city or town may spend, must come alike from taxes which the people pay. It is undoubtedly true that modern changes have made it necessary to the public welfare that the General Government shall take charge of certain things which have hitherto been left to the several States. This does not alter, however, the sound Republican-Democratic doctrine, that local matters should be left to the localities interested. In the first quarter-century of the Nation's life there was reason in the claim that a national system of highways should be provided by the General Government. No such claim can now be maintained. Every State is entirely competent to act for itself in the matter of the maintenance and improvement of its highways, and there is no need whatever for the National Government to interfere.

As for the proposal to increase the "Road Inquiry" bureau's appropriation from $8,000 to $150,000, it should be understood that the functions of this bureau are practically confined to advertising and booming the "good roads" movement; and as has already been noted in these columns, its campaign has been conducted with more zeal than wisdom. We see no reason why public education in methods of road improvement cannot be as well or better conducted by the separate States as by the General Government. The conditions in different States are so diverse that methods which are applicable in one State are often of no use in another. The ability of the Road Inquiry Bureau to spend anything more than its old appropriation with corresponding public benefit appears very doubtful.

The practice of requiring that punched holes in bridge and structural work shall be reamed before the members are assembled has become a common requirement of specifications in recent years. In the discussion upon Mr. J. W. Schaub's paper before the Western Society of Engineers,* it was pointed out that there are considerable difficulties in punching and reaming where material of considerable thickness has to be handled, and that for a large class of the work which bridge shops now handle it is as cheap or cheaper to drill the holes direct from the solid metal as to punch and ream them, provided, of course, that a shop is fitted with a proper equipment of multiple drilling machines. Naturally, manufacturers are not likely to instal this so long as punched work is accepted on the majority of orders; but with the steady increase in the number of engineers who insist on first-class workmanship, we are likely soon to see bridge-shops designed to drill all holes from the solid.

THE NICARAGUA CANAL BILL IN CONGRESS.

There appears to be no sort of doubt that at the coming session of Congress a bill will be passed for the construction of a canal across the Central American isthmus. That public sentiment, taking the country as a whole, is strongly in favor of Government construction of such a canal, is entirely clear; and it is also true that there is not and has not been any considerable opposition to the canal project itself in Congress.

As many of our readers will recall, a bill for the construction of a canal across Nicaragua passed the House of Representatives on May 2,† and is to be taken up by the Senate as a special order when it reassembles on Dec. 10. At that time, it is expected that a preliminary report by the Isthmian Canal Commission will be before Congress; and action upon the enterprise can therefore be taken with an intelligent understanding of conditions to be met and with expert advice as to the best methods to be pursued which was not available at the last session of Congress.

While nothing has been officially made known as to the character of the report which the Commission will make, the "New York Herald," of Nov. 24, asserts that it will recommend the Nicaragua route; that a canal of 30 ft. in depth with the permanent structures designed for an ultimate depth of 35 ft., will be advised; that the cost of such a canal is set at $120,000,000, while a 35-ft. canal is estimated at $175,000,000; and that the location across Nicaragua will be practically identical with that made by the Walker Commission and fully described by Mr. E. S. Wheeler, the Chief Engineer of that Commission, in our issue of July 12.

We give this advance report for whatever it may be worth; but there is good reason to believe that it corresponds closely to the facts. From the outset, the probabilities have been strong that the Nicaragua route would be the one finally selected. It counts for not a little in this matter on which Congress has to finally pass that Nicaragua, and not Panama, is the popular favorite. The extensive booming and advertising which the Nicaragua route received in the palmy days of the old Maritime Canal Co. had their effect on the popular mind; and it is difficult, on the other hand, to dissociate the name of Panama from the fraud of the De Lesseps regime. For these reasons it would require, we believe, a very strong presentation by the Commission in favor of Panama and against Nicaragua to induce Congress to adopt the former instead of the latter route.

We have faithfully presented to our readers without prejudice complete information regarding both these projects, so far as it has been available, and the showing thus far, it seems to us, has been in favor of the Nicaragua route, especially since the new location was made for the latter by the Walker Commission. From our present information, it appears that the Nicaragua Canal can be built in less time than would be required to complete the Panama Canal, that its cost would not be greatly different from the expenditure required to complete the work at Panama, and that its advantages in location will outweigh any advantages in other respects which Panama may perhaps possess.

Apart from these considerations, however, we have reason to believe that the Panama works could not be acquired by the United States on any terms which Congress would favorably consider. The existing French company could not, in justice to its stockholders and its obligations to the old company which it succeeded, turn over its enterprise to the United States except on the payment by the latter of a large sum of money. But strenuous opposition would surely be encountered in Congress to the payment of anything more than a nominal sum to the French Panama Canal Co. It would, we believe, be impossible to pass such a measure through Congress, unless the Nicaragua route were shown unmistakably to be out of the question as an engineering proposition.

As the case stands, therefore, it seems certain that Panama is entirely out of the game. The undertaking of the Nicaragua project by the United States will doubtless mark the end of the Panama enterprise, for it can hardly be possible that many more millions can be found in France to pour into this work. It still lacks at least a decade of years and a hundred million dollars of completion; and if finally finished, it would have to meet the competition of a parallel canal under Government ownership and control and able to reduce its rates of toll to any desired amount if necessary to draw business from its rival.

Taking it as settled, then, that Congress is to authorize the construction of a Nicaraguan canal at the coming session, let us see what ought to be provided for in connection with such legislation.

In the first place, it may be pointed out that the outlook for practical action has been greatly improved by the disappearance from the field of the private concession-holders, who made such strenuous endeavors in former years to have the Government pull their chestnuts out of the fire. Both the Maritime Canal Co.'s concession and that granted to the Eyre-Cragin syndicate are as dead as the traditional door nail. There is no longer a question of buying up franchises of doubtful validity or paying for abandoned surveys. The Government can, therefore, proceed, and indeed there is reason to believe has already undertaken, to negotiate with Nicaragua concerning the terms on which the United States can construct the canal as a Government work. Even the long-standing dispute as to the boundary between Nicaragua and Costa Rica has been adjusted, so that it is no longer an obstacle in the way of obtaining full control of the canal route. It is also reported that Nicaragua is disposed to grant to the United States the full concessions which are desired on terms that will not be deemed exorbitant.

The only remaining obstacle, therefore, to the undertaking of the enterprise by the Government is the existing Clayton-Bulwer treaty with England, under which the two nations agreed, nearly a half-century ago, that neither would undertake a ship canal across Nicaragua without admitting

*Eng. News, Oct. 11.
†See Eng. News, April 26, p. 272 and May 10, p. 304.

the other to an equal partnership in the enterprise. Unquestionably this treaty should be formally abrogated before the United States proceeds with this work. Men of honor and honesty do not deliberately ignore the terms of a verbal contract, to say nothing of a written one, and those who do are amenable to law. Surely the nation should pursue no less honest and honorable a course, and should commit no breach of international law and custom.

As our readers will recall, England has, in fact, consented to the abrogation of the Clayton-Bulwer compact and the formation of a new agreement in its place, which was drawn up by Secretary Hay and Lord Pauncefote a year ago. The questions arising from this new treaty in connection with the canal were fully discussed in our issue of Feb. 22 and March 8 last, and need not be further considered here, save to express the hope that Congress, in providing for the canal's construction, will also provide for observance of our proper international obligations.

We have said above that the Hepburn bill, which passed the House on May 2, will come up in the Senate on Dec. 10. That it will also pass that body seems entirely probable; but before its passage, it ought by all means to receive radical amendment. In fact, we know it to be true that many who voted for the bill in the House did so with little regard to its form, and with the full expectation that it would receive radical amendment before its final passage.

The most notable defect in this bill, and the only one which we shall at this time consider, is the failure to provide any method of carrying out the work of construction; further than that, "The President shall direct the Secretary of War to excavate and construct, etc."

Surely, in providing for so great an engineering work it is worth while to arrange some more adequate organization for carrying out the work than the Hepburn bill contemplates. The War Department is already overburdened and more than overburdened. The Corps of Engineers, on which the responsibility would fall, has its hands more than full with the care of river and harbor work and fortifications, with the other routine duties that fall to its lot and its responsibilities in connection with the work of active campaigning. Besides this, the red tape and the statute restrictions which surround work carried on by the Corps of Engineers make it impossible for it to carry out so vast a work as the Nicaragua Canal will be in an efficient and economical manner.

This is a matter which closely concerns the engineering profession, and upon which it has a right to be heard. American engineers are deeply desirous that this great work, when carried out by the United States, shall be performed in a manner that shall bestow the greatest credit on American engineers and engineering methods. Let us have no Panama scandals and no Carter frauds in connection with this work, and let a system be adopted at the outset which will ensure honesty and maximum efficiency in all the conduct of the work.

As we have said before, all experience goes to show that these ends can best be accomplished by placing the whole work in charge of a select expert commission, to be appointed by the President—just such a body, for example, as has been investigating the comparative merits of different routes.

Such great engineering works as the Chicago Sanitary Canal, the Boston Subway, the New Orleans Drainage system, the Cincinnati Water-Works, and the New York Rapid Transit railway are recent examples of the success of the Commission system of conducting large public works. We risk nothing in saying that with no other system has equal success been attained.

In the make-up of any such commission the engineers of both the army and the navy and those who have attained a wide and honorable reputation in civil life, should all be represented. A body of such men can be safely trusted to keep its honor above all suspicion, to detect and checkmate every attempt to defraud the Government and to make such wise decisions upon the difficult engineering problems which will inevitably be brought before it as shall best ensure the safety and success of the entire work.

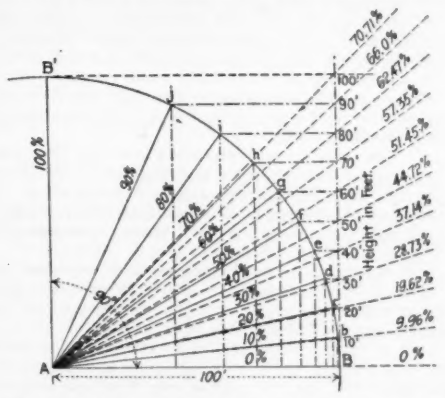
We can hardly doubt that this method of carrying out the work would be the choice of the Executive as well. The successful inauguration of work upon a great interoceanic canal will be not the least of the triumphs of Mr. McKinley's administration. By the provision of a proper organization at the outset, the enterprise will be safe from disturbance through any vicissitudes of politics that may occur during its construction. Congress, in the Hepburn bill, has already manifested its willingness to trust the entire matter to the discretion of the President and his Secretary of War. It can surely trust them, then, to select men to whom this task may safely be delegated.

LETTERS TO THE EDITOR.

Computing the Resistance Due to Very Steep Grades.

Sir: In calculating the resistance of exceptionally heavy grades on the cable inclines of the Arizona Copper Co. and the Detroit Copper Co. on which ore cars are run and which have grade rates of 15 to 40 ft. per 100 ft., it became evident that the usual definition of rates of grade, as used in railway work, would not give accurate results. I suppose that 99 out of 100 railway engineers would say offhand that a 1% grade was a rise of 1 ft. vertically to 100 ft. of horizontal distance, and that a 100% grade was a vertical rise of 100 ft. per 100 ft. horizontally.

Wellington, in his "Economic Theory of Railway Location," gives the rule: "Grade resistance in pounds per ton = rate of grade per cent. × 20." That is, the resistance of a 1% grade = 1 × 20 = 20 lbs. per ton, and, as Mr. Wellington says, this can be readily shown to be correct by the general theory of the equilibrium of forces. From this, it is evident that the resistance of a 100% grade is 100 × 20 = 2,000 lbs. per ton. From this, it follows that a



100% grade lies in a vertical plane since its grade resistance is parallel to itself and equals the total load, or unity, which can be true while acting in a vertical line only.

Now it is evident that should we lay out a 100% grade for 100 ft., as in railway work, i. e., 100 ft. horizontally and 100 ft. vertically, we would have a grade rate actually 70.71%, as shown in the accompanying figure No. 1, and the grade resistance would be 70.71% × 20 = 1,414.2 lbs. instead of 2,000 lbs.

In the figure, nominal grades of 10 to 100%, as they would be laid out according to and within the limits of railway practice, are shown by the dotted oblique lines, and their actual grade rates are noted by figures at the extremity of said lines. The actual grade rates of 10 to 100% are shown by the solid straight lines, the 100% being vertical.

From this, it is evident that actual grade rates must be determined by dividing the vertical rise of the grade line by its actual length and not by its horizontal projection. Thus, the actual 90% grade shown in the figure must be determined by dividing its rise, 90 ft., by its length, Aj, or 100 ft., and not by its projection, A K. The 100% grade has no horizontal projection. This is also evident for, if, in the figure, we let the line, A B, represent a horizontal grade line 100 ft. long and then begin to lift the end B upward, rotating it about A as a center, in order to change the grade to 100%, we shall have to lift the end B 100 ft. vertically above A, and, to do this, we must pass B through the arc B B' and make it coincide with B'. The line, A B, would, at that instant, become vertical.

Clifton, Arizona, Nov. 12, 1900. J. L. Campbell.

The Value of Good Roads to the Farmer.

Sir: I wish to thank you for a copy of Engineering News of Nov. 15, containing your editorial and Prof. Baker's article on "Fallacies and Facts Concerning Good Roads." So far as my little book on the subject, written a good many years ago, is concerned, I am delighted to find that I escaped so easily. I own up at once regarding the fallacy of estimating the loss on good roads by charging up so much per horse per year and counting in all of the horses. On the other hand, I am inclined to think that there is a somewhat less important fallacy in the statement made by Prof. Baker and apparently adopted by you—that the farmers haul their products to the market at the time of the year when the roads are in best condition (p. 324, first column). This is probably true, but is not this also likely to be just the time of the year when the farmer might use his horses to the best advantage on the farm with the possible exception of a short time in the middle of the winter? With good roads the farmer would select the days for going to the market when neither he or his team could be profitably employed on the farm, whereas under present circumstances, the days when he cannot work profitably on the farm are the days when the roads are the most impassable. (See Road Legislation, p. 13.)

I am happy to find that I made no serious mistake apparently in the kind of road legislation that I advocated and that I was not foolish enough to suggest stone roads for our American farming districts except in very rare cases, where roads were of state importance. I certainly think that both Prof. Baker and you have done a very great service on the whole question by your articles, and wish to thank you for them.

Very sincerely yours, J. W. Jenks.
Cornell University, Department of Political Science.
Ithaca, N. Y., Nov. 23, 1900.

(The question as to the financial value of stone roads to a farmer for marketing his crops simmers down to this: A farmer is obliged to keep a certain number of horses the year round to do the necessary work on the farm, and in most cases the farm work can be so arranged with little inconvenience that these same horses can do all the necessary hauling of crops to market. Of course, milk producers, market gardeners and ordinary farmers living a long distance from a railway sometimes have to keep extra horses for hauling purposes; and farmers of that class may somewhat reduce the number of such extra horses if they have the advantage of good roads; but the farmers of this class are comparatively a small proportion of the whole.

Of course, as Prof. Baker has pointed out, hard roads have an advantage to the farmer from a social point of view, especially in regions where the natural soil is such as to make the roads almost impassable during a large part of the winter and spring. They ought to be advocated, therefore, for what they are—a luxury and not an economic necessity. Build good roads where they can be afforded; but beware of the policy, now being so perisistently advocated, of loading towns and counties and states with a great burden of bonded debt, to build "good roads" in the expectation that they are going to pay for themselves.—Ed.).

Railway Construction in India.

Sir: The work of railway construction in India is carried on by four distinct agencies as follows: First by the Indian government, as state undertakings under the supervision of their own engineers; next by the agency of the existing main line companies, which are more or less guaranteed by the state; then by the agency of subsidiary or branch line companies, which are generally subsidized, and lastly by the native states and princes at their own expense and for their own benefit. The government usually undertakes projects which are desired for other than purely commercial purposes, such as railways necessary for the protection of areas subject to famine and drought, those desired for political reasons, or for strategic military lines. The cost of these railways is met out of the revenues of the empire, and their success or non-success is a gain or loss, as they case may be, to the general taxpayer, but the indirect advantages of a railway in India, even if financially unremunerative, counterbalance the disadvantages.

The stores of materials, girders, permanent way, rolling stock, station and other machinery, in fact everything that can be imported from England and cannot be manufactured or produced in India is supplied by British manufacturerers or in some cases by Americans through the agency of the India Office Stores Department, London, to whom Messrs. Sir Alex. M. Rendel & Sons are the consulting engineers. The guaranteed or main Indian railway companies also import most of their stores and materials, as India is not a manufacturing country in the general sense of the word. Of course the railways have their workshops, but they confine themselves almost wholly to repairs. The East Indian Railway, at its Tamalpur shops, has built some locomotives and has rolled rails, but even this works is an infant industry compared with works in the United States and Great Britain.

New railway projects put forward for construction by the government, or as part of an existing guaranteed main

line company, are included in what is known as a "State Programme of Railway Construction." This programme has been framed for a sum of about $65,200,000 for expenditure during the three years 1901 to 1902, or an average of $21,730,000 per year. Of this amount about half is allotted to the development of the existing railways and half for the provision of new lines of railways. Now the sum of $10,865,000 a year cannot do much towards the rapid development of railway construction in a country the size of India. The government of India have therefore invited the co-operation of private enterprise to construct subsidiary branch or feeder lines to the trunk or main lines. These must not ordinarily exceed 100 miles in length, and the form of financial assistance offered is either an absolute guarantee or a rebate by the main line. An absolute guarantee, however, must ordinarily be provided for in the State Programme of Construction, and this, as already mentioned, has now been fixed for the three years ending March 31, 1904. Hence private enterprise can only take up projects outside that programme upon "rebate terms." Under those terms it may be provided that the main line company may make a payment to the branch line company sufficient to give a return of 3½% per annum on the actual expenditure charged in the capital account of the branch line company as entered in rupees in the company's books in India.

This dividend is of course dependent on the amount of the net earnings from the total traffic of the branch line and of the traffic interchanged with the main line being enough to yield that return. A still higher return may be made, however, if the net earnings of the branch from its own traffic are sufficient to pay more than 3½%. Applicants for concessions for the construction of branch lines must satisfy the government that they are in a position to command substantial support financially in order to establish their bona fides, and must be prepared to accept the provisions of all acts of the legislature which are applicable to Indian railways. The gage of any proposed railway is also subject to the approval of government in each case. The existing gages in India are the standard, 5 ft. 6 ins., the French meter gage and the smaller gages of 2 ft. 6 ins. and 2 ft. for light railways and steam tramways which are not worked with all the restrictions of railways.

I. A. Ten Broeke.

Simla, Punjab, India, Oct. 18, 1900.

Why So Many Railways Are Badly Located.

Sir: Having been engaged in railway engineering about thirty years of my life, chiefly on location and construction, I naturally take an interest in most subjects which pertain to engineering, and more especially in subjects which pertain to my part of the shop. And now that we seem to have all the information on the subject of mending steel tapes, and on the manner of setting slope stakes, I am expecting to see the annual effusion of setting stakes for curve transition; or if not that then probably an extended discussion on the subject of why surveys should be commenced with station "0;" or why stakes should be numbered to read from the top downward, or some other equally important and equally less understood subject. But without intending to be facetious, it seems to me that there are far more important subjects which should be discussed, which might be not only of interest to engineers, but of great advantage to the people who invest their money in railways.

The foundation of all the principles of the economy of transportation by railroad is in its location; and yet there has been less said on that subject by technical writers than any other. In fact there is nothing in any of the text books which is of any value to the young engineer; and no person has ever made an attempt at the subject, as though he meant business, excepting the lamented Wellington, and had he been spared longer I have no doubt he would have gone into the subject much further. He was undoubtedly on the right track, and I am only sorry that I do not feel myself equal to the task of taking up the subject where he left off.

The facts are that too many of our railways are located by men who do not understand the first principles of what is expected of a railway when it is completed; and it is safe to say that out of something over 185,000 miles of railway in this country less than 20% occupy the ground they should.

The practical and experienced engineers of the country understand why this is so, but as a matter of policy they "keep mum," and yet they cannot give any very good reason why.

The birth of railway enterprises has generally been in the private office of some one who has noticed in the daily paper that the price of steel rails has dropped, and he immediately multiplies the price per ton by the number of tons per mile—a light rail of course—and that by the number of miles from X to Y, and he can then in his mind's eye see trains running between the two points at the rate of sixty miles per hour,—with his special car attached! He calls in his partner, and along with the president of a local bank, a shoemaker, a wagonmaker and a farmer—and the lawyer, I must not forget, must be in the play, as he must draw up the corporation papers, get bonds voted, right of way donated, etc. All of these men are well to do and a success in their own line.

Behold now this great array of transportation talent, seated around a table with a map spread before them, about to build a railway! The first meeting develops the fact that they are not quite ready to run trains, and it dawns on some one that they should have a survey made, more especially to get the exact distance between the two points. In all probability the county surveyor is called in, as he has the instruments and he will do to make the survey. He is shown the map and is instructed as to where the line shall be located, and in all instances where possible to follow the section line, as it will make the right of way easier to obtain. In the meantime while the survey is being made, the bonds voted, subscriptions to the capital stock obtained, etc., the president is authorized by resolution of the board of directors to obtain the services of a construction engineer, in order that they may be prepared at the proper time to rush the work. The county surveyor or locating engineer, after brushing up on his mathematics, and ordering a field book by telegraph, finds that he should have a line of levels follow him and a profile made of his survey, and after consulting with the president he is authorized to engage a leveler at $40 per month. He also refers to his book, giving the radii of different curves, and he is not long in ascertaining the fact that in changing direction a curve of short radius does not cut in so far—which is of great advantage where following section lines, as the cost of right of way will not be so great.

The survey is completed. The chief engineer has been engaged, from some city where he has been occupied building sewers, viaducts, etc., at the tremendous cost of possibly $150 per month and his expenses when away from the office. He is shown the profile and an elaborate map of the line upon which he is to establish grades and build a railroad. He first proceeds to properly equip his office, gets an experienced draftsman, blue print apparatus, etc. He probably establishes grades, designates bridges, station grounds, etc., before he goes over the line, as the board of directors are in a great hurry for the approximate estimate, in order to let the contracts. When this is done it reveals to the board of directors that it takes other things besides rails to complete a railroad.

But after many trials and tribulations everybody connected with it learning something every day—but a day too late—we behold the railroad completed and it is opened with a great flourish of trumpets amidst a blaze of fireworks, congratulations, speeches, etc., and the first train has gone clear through without getting off the track or going through a bridge.

It is now ready for business—and a receiver. The latter is promptly asked for and easily obtained. After a few bloodless fights between two armies of legal talent, the railroad is sold out under the hammer for about the price of the rails at the mill, to some "Octopus" and relocated, rebuilt and used as a feeder.

This statement may seem overdrawn and ridiculous, but it is not, and the monuments scattered all over this country, as well as the evidence of the experienced civil engineers fully confirm it.

I cannot resist the temptation to relate a story which has been properly vouched for. Without giving away the location I will say that it was less than one thousand miles from St. Louis, where a railway company had been formed about on the lines I have noted above. The engineer had completed his approximate estimate, giving all the items of cost, and among these items were a number of million cubic yards of overhaul. When this report was being read by the secretary to the board of directors and that item was reached, one of the members of the board said in astonishment: "Good God! have we got to furnish all these men with overalls?"

These conditions are not the fault of the engineers. It is the fault of the people who having use for their services do not know a good one from a bad one; and as explained by Mr. Wellington: "The engineer's ability is publicly measured by the vast and stupendous structures which he has reared and not by those which he has been able to avoid." The hundreds of millions of dollars which have been worse than thrown away because of bad locations will never be known. The board of directors who make the annual inspection viewed from the glass end of the private car will continue to wonder why it is that the business cannot be done for a less cost; and they probably come to the conclusion that the wages paid are too high; and, if the road should happen to have any engineers in its employ, that they will hereafter manage to do without them. Unfortunately the engineer is looked on generally as a kind of necessary evil, and the sooner he is disposed of the better. All this in the face of the fact that the most successful companies on the continent always have made and continue to make a liberal use of them.

I imagine that I can hear the reader asking the question, "What is his remedy?" I have no remedy. I am simply "kicking against the pricks." I have no way of telling the world how to select engineers to do work upon which there is no one to pass judgment when it is done. I think I can tell whether an engineer is capable of making the right location when I have witnessed his mode of work and have tramped over the ground with him, and find that he understands that the perfection of a railroad is a straight line and level grade; and that when he departs from either he does it at an added expense for future operation. The Irishman in bragging about the roads in the old country as compared with the roads in this country said "they were all down hill."

Our text books have never gone into the subject of the value of grades and curvature, and right there is the basis of it all. The question is, "How much distance can I afford to make, or expense to incur, in order to avoid either?" But this is the question which the technical writer should solve. It is possible of theoretical and mechanical demonstration; and it is as feasible to prepare tables to cover these subjects as for any of the other much used tables. The amount of maximum grade and maximum curvature also has a value, and the less of either we have the more economical the operation. I have many times heard engineers make use of the expression "So long as we have to use it in one place, we ought to use it whenever we can save a dollar in construction." This is not so, and its fallacy may be easily demonstrated.

Bad locations are as often as otherwise due to the great hurry to keep out of the way of the graders. This of course is not the fault of the engineer, but that of the man who is pounding him on the back calling for a line of stakes. The man who is doing the pounding is probably the same man we have all met with in all countries, who can "tell by his eye" just where a location should be made and who expresses great sorrow in the fact that he has not full charge.

The first-class locating engineers of the world are born and not made; and they are scarcer than the proverbial chicken's teeth. It comes just as naturally to such rare men to take in the topography of a whole country at a glance as it was for Blind Tom to create music. Why this is so the writer cannot himself explain, and neither can he explain why such engineers are so scarce. There are plenty of engineers of first-class ability in other lines, who would not dare to go out of sight of camp alone without a compass, for fear of getting lost; and if they went they would probably make up their minds that the compass had gone crazy.

The question of nicely fitting a line to the ground after the route has been selected and the maximum grade and maximum curvature determined, is a small matter and is more mechanical than otherwise, as compared with the great economical question. But it is fair to say that there are good, bad, and indifferent men who profess to do this kind of work. Do not understand me to say that a man with this intuitive knowledge of country needs no other knowledge to make his services of value. He needs not only education, but experience before he himself can realize wherein his ability lies, and the more he has of both, the sooner will his services be of value.

I have endeavored to make myself clear on this subject and show that in most cases at least the foundation of economy in the operation of railroads lies in the beginning, and not after the road is constructed. It is impossible to so construct a badly located road that it can be operated with economy. Some managers seem to think that the economy on their part consists in seeing that their engineer parties in the field are compelled to live on pork and beans and no pie. The mistake starts in at the beginning and continues to the end.

Yours respectfully,

P. F. Barr.

Phoenix, Arizona, Nov. 12, 1900.

(The picture presented by our correspondent is one which many engineers will readily recognize. It should be pointed out, however, that a large proportion of the railway construction of the present day is done by established railway companies, and in a much more intelligent and systematic manner than was the case with some of the old-time railway projects. We may cite for example the admirable instructions to locating engineers prepared by Mr. E. H. McHenry, M. Am. Soc. C. E., as Chief Engineer of the Northern Pacific R. R., and printed in our issues of April 20 and April 27, 1899.—Ed.)

THE FAILURE OF AN ELEVATED WOODEN WATER tank at Cedar Falls, Ia., is reported, with little damage except to the structure. According to "The Manual of American Water-Works," the tank was 30 ft. in diameter, 20 ft. high, placed on an iron trestle 75 ft. high. The tank was built, with the water-works, in 1887-8.

ASPHALT AND WOOD BLOCK PAVEMENT is being laid side by side in Boston, as noted very briefly a few weeks ago. The following particulars are from the November bulletin of the Boston Society of Civil Engineers:

Tremont St., from Scollay Sq. to Boylston St., from which the street railroad tracks were removed last fall, as the result of a popular vote, is being paved with Trinidad Lake asphalt: at the junction of Park St., where the grade is heaviest, one-half the width of the street is being paved with wooden blocks for a length of about 350 ft. The intersection of Tremont with School and Beacon Sts. is to be paved with the same material. The blocks are 4 ins. deep, 4 ins. wide and 8 ins. long. Long-leaved Georgia pine, free from sap, is used, and the wood has been impregnated with a resinous creosote preservative. The blocks are laid as closely together as possible, on a 6-in. Portland cement concrete base, with a 1½-in. sand cushion; the joints are filled with sand. The steepest grade upon which wood paving is laid is about 5%.

A NEW STEAM WHARF CAPSTAN.

The utility of power-driven capstans and hoisting appliances about docks and wharves is generally recognized. Steam-driven capstans are common on vessels, the steam apparatus being usually placed below the deck. On a wharf this arrangement is frequently not possible, and at the same time the construction must be compact, simple, and protected from the elements

The capstan herewith illustrated has been designed with these requirements in mind. The engine, with the power-transmitting machinery and the valve gears, is enclosed in a substantial cast-iron case. The steam cylinders, valve chests and steam piping, however, are on the outside of this case, where they are readily accessible. The bored cross-head guides are cast in one piece with the cylinders, the whole being firmly bolted to the sides of the box. The two engines are coupled 90° apart, to a common crank-shaft, at the middle of which is a worm gearing with a worm-wheel on the vertical shaft of the capstan. The lower side of the worm dips in a bath of oil. The crank-shaft carries also two eccentrics for each engine, which drive a Stephenson link valve-gear. The latter is controlled by the lever seen at the front of the capstan.

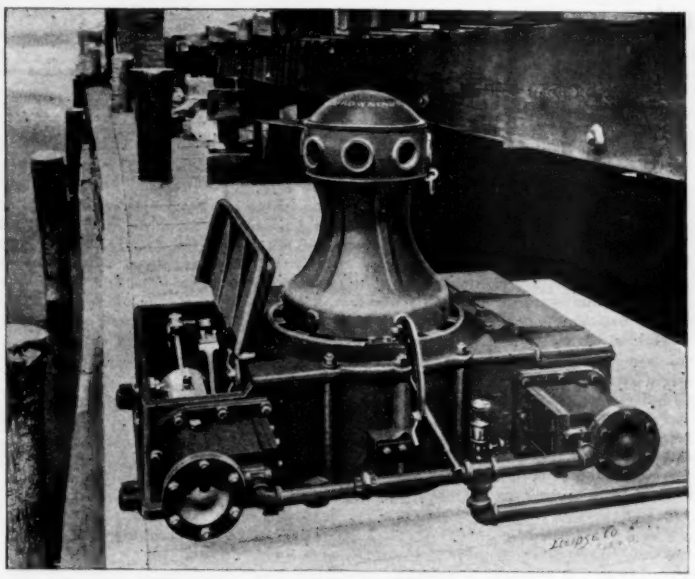


FIG. 1.—STEAM WHARF CAPSTAN.
Made by the Browning Engineering Co., Cleveland, O.

The spool is driven from the head by means of a key. The ring attached to the latter may be seen at one side of the head in Fig. 1. By removing this key the spool may be allowed to unwind of itself without reversing the engines.

This capstan has been designed and is being manufactured by the Browning Engineering Co., of Cleveland, O., and we are indebted to that company for the cuts used in illustrating this article and the information presented.

NATIONAL GOOD ROADS AND PUBLIC IMPROVEMENT CONVENTION AT CHICAGO.

A "good roads" convention was held at the Central Union Hall, Chicago, Nov. 19, 20 and 21, under the auspices of the Interstate Good Roads Association. Delegates were present representing some 24 states, and the Dominion of Canada. There were also many persons present, on account of their interest in the general subject of road improvement. The attendance was not large, however, and as several thousand people were reported to have availed themselves of the special rates made by the railways for this occasion, a resolution was adopted to the effect that the railways were being imposed upon and that in future the reduced return rates should be granted only to those persons who registered and answered to the roll call. The meeting was not of a technical character, but was intended mainly to arouse interest in the general subject of road improvement.

On Nov. 19 the opening address was made by Mr. W. H. Moore, of St. Louis, who is President of the Interstate Good Roads Association. He reviewed the history and work of this association, in which several western states are represented. After referring to the importance of road improvement to the entire community he pointed out that two years ago Congress made appropriations of nearly $25,000,000 for river and harbor improvement, and only $8,000 for road improvement. He considered it quite time that much larger appropriations should be made for the latter purpose, and suggested that Congress would be quite ready to grant these if made to understand that such appropriations were really desired by the people. A brief address on behalf of the mayor was made by Mr. S. Mayer, and Mr. Charles Truax, of the National Business League, was elected temporary chairman. An address was delivered by Mr. Martin Dodge, Director of the Road Enquiry Office, of the U. S. Department of Agriculture. Several committees were then appointed.

At the afternoon session, Mr. W. H. Moore was elected Chairman, and Miss Harber, Secretary of the Interstate Good Roads Association, read her annual report. Mr. Andrew Patullo, of the Canadian Parliament, then made an interesting address, in which he took occasion to refer to the great need of road and street improvement in Chicago. He thought the national government should assist in the construction of good roads as feeders to the railways, and pointed out that good roads would aid materially in checking the tendency of the younger generation to move into the towns on account of the discomforts of farm life. While the statute labor law is not now suitable to meet the conditions, it was a good thing in its day. The men who "work out" their road taxes are intelligent enough, but they do not work under skilled direction, and consequently much of the work, even when honestly done, is valueless. A paper reviewing the history of roads from the days of the Romans, and showing the relations of roads to commercial and agricultural industries, was read by Gen. Harrison G. Otis.

At the meeting on Nov. 20, Mr. R. Goit, of Kansas, read a paper on "Drainage and Culverts," the principal feature of which was that head rather than size of pipe is of greatest importance in relation to the capacity. It is very common to use a 24-in. pipe with a 2-in. fall in its length, while a 16-in. pipe laid with a 24-in. fall would have greater velocity, equal capacity and a greater depth of material over the pipe. Mr. W. H. Moore referred to the disgraceful condition of Chicago's roads and streets and to the failure of the city Public Works Department to send any of its street engineers or inspectors to the meeting. Mr. A. W. Campbell, Highway Commissioner of Ontario, Canada, gave an address on "Organization for Local Road Improvement," in which he suggested that "improved roads" would be a better than "good roads," and arouse less antagonism. The present necessity is for a general organization to systematize the work and prevent waste or misuse of funds. When this has been perfected, it will be time to ask the government for appropriations. This plan would include national, state, county, township, municipal and local organizations. If people at large will not take an interest in the matter, how can they expect the farmers to do so. The statute labor law was adopted when men had no money, and had to do all the work for themselves, in clearing the ground, grubbing the stumps, bridging the streams, and building "corduroy" work over the swamps. Things have changed since then, and now there is needed a system which will be less cumbersome and far more efficient for the class of roads needed under modern conditions. Education as to the meaning of the "good roads" movement is much needed, as there is a popular idea that it means stone roads and expensive roads in every case. Under the present system of electing new pathmasters, or road supervisors every year, there is no chance for permanent improvement. The county or other authorities should appoint a permanent commissioner, and have a plan made of all the roads in the district, upon which should be indicated the required uniform width for main and cross roads. Every spring the commissioner should inspect the roads and report upon the repairs, bridge and culvert work, etc., required. He should be furnished with proper equipment, including a grading machine, road roller and a stone crusher, if the district has stone roads. A proper system of maintenance should also be adopted. The construction of streets and the organization of street departments are fully as important as road construction and maintenance, but in a city over-ridden with politics, like Chicago, good streets would not be a paying investment for the professional politician. Senator Earl, of Michigan, referred to the movement in that state, and the construction of sample roads; one of these is a macadamized road in a stone district, the other is a gravel road on a stone foundation.

At the afternoon session, Mr. H. H. Gross, Illinois agent of the U. S. Road Enquiry Office, read a paper on "The Effects of Good Roads on the Value of Agricultural Lands," and intimated that the state legislature will probably pass a "hard road" law this winter. Resolutions were adopted as follows, and a committee will be appointed to present these resolutions to Congress:

We earnestly recommend (1) that our representatives in Congress be urged to obtain, if possible, an appropriation of at least $150,000 per year, to be applied to the uses of the Office of Public Inquiry under the Department of Agriculture, in extending its work of education and instruction; (2) that the Postoffice Department adhere to its policy of requiring the maintenance of good roads as a condition necessary to the free delivery of the mails.

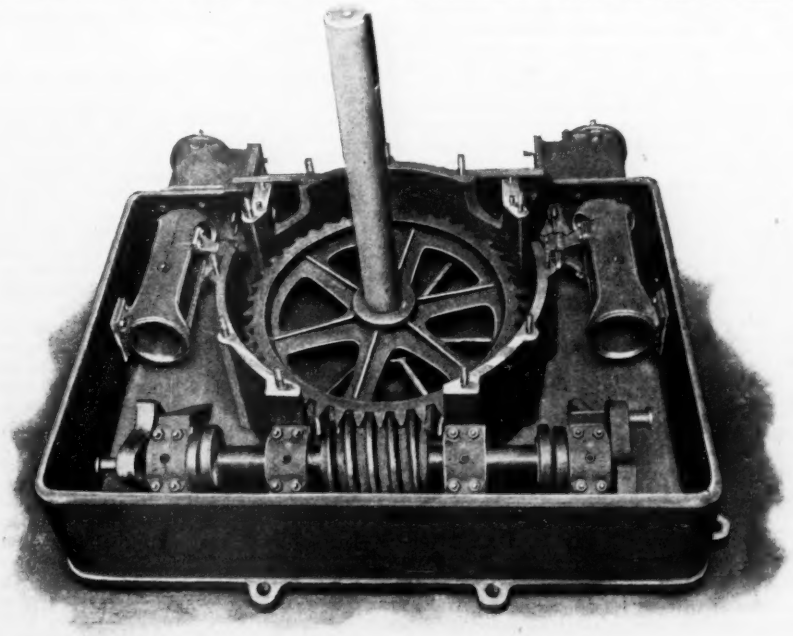


FIG. 2.—INTERIOR VIEW OF CAPSTAN, SHOWING ENGINES, CRANK-SHAFT, WORM-WHEEL AND VERTICAL SHAFT.

At the meeting of Nov. 21, a paper by Mr. E. G. Harrison, of New Jersey, was read, giving a review of the work of promoting the road improvement question by the construction of sample roads. The rest of the session was wasted in matters having no relation to the object of the convention. There was first a long address on Canada, its

agriculture, its minerals, and its politics, and after this the representatives of three or four coming exhibitions were allowed time to advertise their projects. Some of the more earnest of the delegates entered a protest against this introduction of extraneous matter, but the majority seemed to be willing to take anything that came along. Prof. J. R. Crane, of the University of Illinois, briefly referred to the fallacies in good road economics recently presented in a paper by Prof. I. O. Baker, which was discussed in our issue of Nov. 15. Mr. Martin Dodge, of the Road Enquiry Office, attempted to defend the misleading statistics emanating from that office, but his defense resolved itself into a mere expression of belief in the accuracy of the figures. No opportunity was given for any further discussion on the subject. A paper on "Oiled Roads" was read by Mrs. Mary Lynde Craig, of California, and this brought forth considerable discussion with detailed information from some of the other delegates from California. A paper on "Rural Free Mail Delivery," by Mr. J. L. Waite, postmaster of Burlington, Ia. (and editor of the Burlington "Hawkeye"), was very favorably received, but a wild project for government aid to road construction by means of a special issue of currency received scant attention. Mr. Herbert M. Wilson, of the U. S. Geological Survey, briefly described the geological and topographical work of the survey in its relation to roads and road material, and Mr. H. V. Johnson, Mayor of Denver, Colo., described the use of broken basalt rock and of slag from the smelters for road construction.

The report of the Committee on Legislation, which was adopted, made the following recommendations:

(1) That suitable legislation in different states repeal the statute labor laws, substituting therefor the payment of the usual road taxes in cash.
(2) That state legislatures make provision for the employment of convict labor in preparation of material for the construction of public roads.
(3) The passage of suitable state aid laws and the appointment in every state so legislating of non-partisan highway commissioners.

One important result of the convention was the organization of a permanent society, under the name of the National Good Roads Association; President, Wm. H. Moore, of St. Louis, Mo.; Secretary, R. W. Richardson, of Nebraska; Treasurer, Edwin F. Potter, of Illinois. There is to be a vice-president for each state and territory. The headquarters are to be at Chicago, and the next annual meeting will be held at Buffalo, N. Y.

RAILWAY YARDS AND TERMINALS.*

By E. E. Russell Tratman.†

When a train comes into the yard, off the road, some of its cars are to be sent out over other divisions or lines, others to be unloaded, others to be held for repairs or orders, and still others to be distributed to docks, elevators, industrial tracks, etc. Of the through cars, or those which have to go forward in other trains, some will be for fast freight and others for ordinary freight trains, while others are to be delivered by local freight trains at the various stations on the next division. The incoming train first enters the receiving tracks (or yard), where the road engine is detached, and the cars, after inspection and marking, are handled by the yard engines and crews. Through freight trains require little attention beyond inspection and the changing of engines and cabooses. Ordinarily, however, the train has to be broken up, and its cars sorted and classified, either by districts or commodities. When thus distributed, cars for these latter tracks are selected as required for making up outgoing trains, local trains being required to have the cars arranged in station order, so as to have as little switching as possible at way stations. The trains are made up in the departure yard, ready for the road engines to take out. Besides these movements, cars that are defective must go to the repair tracks; cars for which there are no orders go to the storage tracks; and cars which have reached their destination, to the house or team tracks to be unloaded. Empty cars have also to be distributed to the freight house tracks, elevator tracks, coal docks, etc.

The separate "yards" or groups of tracks which make up the terminal yard as a whole, must be so arranged in series that the cars will move steadily forward in the several switching movements, all backward or reverse movements being detrimental to the highest efficiency of working. The receiving yard first calls for attention. It is generally assumed that the length of receiving track should be that of the maximum train hauled. In general, this is a safe proposition; but there are cases where it would not be economical. If maximum trains are relatively few, it may be economy to make the length of the track equal only to that of the maximum average train, leaving the few trains of actual maximum length to be taken care of by special means. Tracks which are too long involve unnecessary length of switching movements, although in receiving tracks this may be reduced by the use of crossovers. The length of track should be the same in all the groups, and if too great a length is provided, the aggregate length of the yard will be excessive, causing waste of time in the movements of the switchmen and engines. It will also necessitate running the cars at high speed, making it dangerous for the men to jump on and off, and inducing liability of injury to cars by collision.

The team tracks, upon which cars to be unloaded by teams are placed, are usually parallel with the yard tracks, but greater economy of space and greater facility in handling the cars, may be effected by running a series of short parallel tracks, in pairs, at an angle from a ladder track. The two special advantages in this plan are: (1) The despatch with which a car may be placed on or taken from any point on any track without disturbing any considerable number of teams loading or unloading other cars on the same track; (2) The advantage of utilizing a short square piece of ground not available for more than two or three short parallel tracks. Car storage tracks should be double ended, or else there is a tendency for old "held" cars to remain neglected at the dead end of the track until under stress of special orders the whole string of cars is moved to get out the old cars. The storage tracks should also be so connected with the classification tracks, that in making up trains the cars can be taken from either the classification or storage tracks as required. Special provision must be made for separating perishable freight, stock cars, etc., from the ordinary freight, so that fast freight trains can be attended to, made up and dispatched with as little delay as possible, and without interference with the general work of switching the ordinary freight cars.

Track scales must be provided for weighing cars, and it has been recommended that such scales should be placed at the entrance to the classification yard, so that cars can be weighed while being switched. The scale should always be constructed with a dead rail, and should be on the switching lead, or on a short track outside of and connected at both ends with this track. The Chicago, Lake Shore & Eastern Ry. has at its main Chicago yard a track scale 100 ft. long, upon which all cars entering or leaving the yard are weighed while in motion (Engineering News, Sept. 21, 1899). Scales with the tables suspended from above, instead of supported by machinery in a pit below the table are considered to have many advantages, but are not extensively used.

Ample crane equipment must be furnished for the rapid handling of freight, and there must be special facilities for the handling of heavy freight. A very convenient appliance is a bridge crane spanning a track and roadway, and having a traveling trolley on top. A wagon with heavy stone or pieces of machinery, etc., can be driven under the crane, and a car placed alongside. The load is then hoisted and traversed by the trolley and lowered onto the car. The crane may be operated by hand or power.

The movement of cars in the yards may be effected in three ways: (1) By coupling an engine onto the car or cut of cars to be moved; (2) By pushing the car with a pole from the engine; (3) By gravity. The first method is slow and inconvenient, causes much damage to cars, and is now rarely used for large or busy yards. The second method is the one now most commonly used, often assisted to some extent by the third method, but this latter method is not employed so much in this country as abroad. In Europe some yards are operated almost entirely by gravity, the cars passing in this way from one set of classification tracks (or "gridiron") to another. In this country, however, the gravity system is usually confined to a few tracks for certain movements. The pole may be attached to the engine bumper or tender, but in large yards the more general practice is to have a poling car coupled to the engine, the pole being hinged and suspended in such a way that it can be set in position against the corner pocket of the freight car by means of levers handled by a man on the poling car. A grade of 0.5% is very generally used where the gravity system is merely auxiliary to poling, but where cars are switched by gravity alone a steeper grade is used. The gravity tracks in the Port Jervis yard of the Erie R. R. have a grade of 1.25%, and are 800 ft. long.

Yard entrances should always be protected by interlocking switch and signal plant, and there are special switch connections which can sometimes be interlocked with advantage. The entire operation of yard switches by hand interlocking is impracticable on account of the length and complications of the connections, but power operation may sometimes be introduced. For instance, all the switches of a ladder track may be operated from levers concentrated in a tower, but they need not necessarily be interlocked. Power operation has been applied with signal success in the Altoona yards of the Pennsylvania R. R. The system has been in service for some years, and works with great ease, reliability and rapidity. Compressed air and electricity are utilized, but the details of the equipment and its operation are too complicated to be described here. The operator controls the switches by push buttons, and when one is thrown an indicator shows when the car sent to that particular track has cleared the switch so that it can be closed again. A somewhat similar system has been installed at the passenger yards of the Grand Central station in New York.

The efficient lighting of yards at night is a difficult problem, and one which has as yet been solved in but few cases. Good lighting is most desirable to facilitate the work of carding the cars and carrying on the various switching movements, but the conditions are very unfavorable. Electric lighting is in many ways the most satisfactory, but great care needs to be taken in placing arc lights so as to avoid long shadows as far as possible. This means the use of very tall poles. With lights badly set, the alternations of patches of bright light and moving shadows of intense blackness (by contrast) are probably more dangerous than a uniform darkness to which the men's eyes become more or less accustomed.

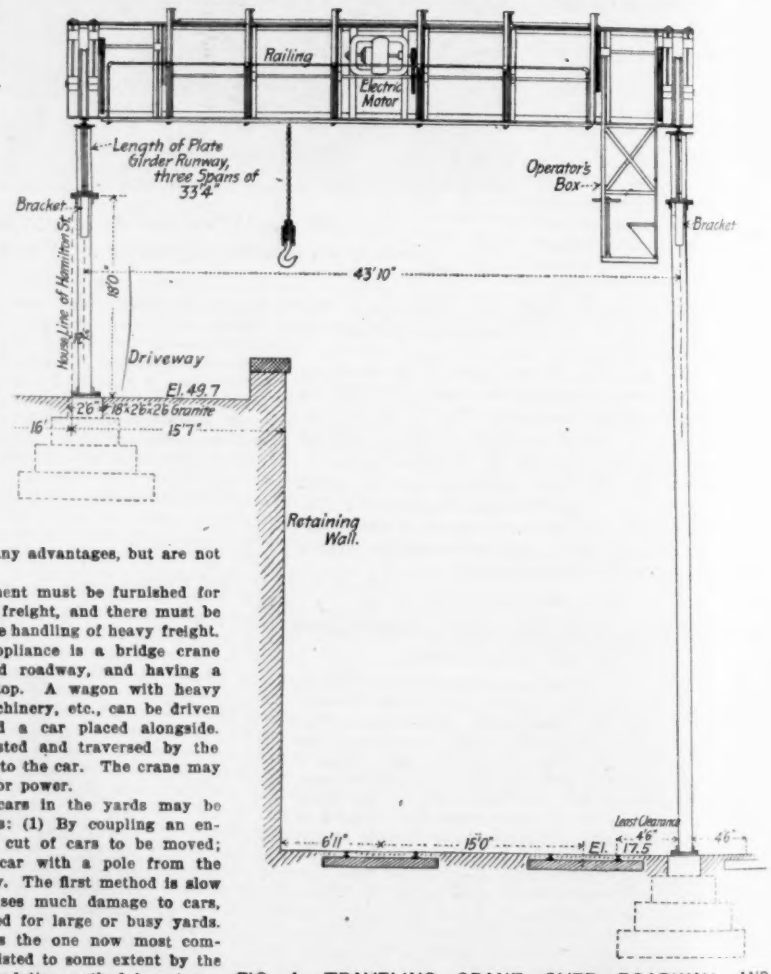


FIG. 1.—TRAVELING CRANE OVER ROADWAY, AND DEPRESSED TRACKS AT THE PHILADELPHIA FREIGHT TERMINAL; PHILADELPHIA & READING R. R.

One of the problems to be met is that of not only attaining efficiency and economy in the operations of handling cars and freight, but of attaining these ends on a minimum area of ground. In other words, the problem of utilizing every square foot of ground to its maximum capacity. The matter will be of increasing importance as our cities grow and land becomes more expensive. In very many cases it will be economical to abandon large city yards, selling the land or utilizing it for more remunerative purposes, and establishing outlying switching yards, with a limited number of tracks to central freight houses. The tall office buildings have set an example of the way in which a small area of ground may be utilized, and in Europe there are many examples of double-deck freight houses, with cars and tracks on at least two levels. The city of London affords many examples of work of this kind, one of the latest of which is the new freight terminal of the Great Central Ry., which was completed

*Abstract from a paper presented at the November meeting of the Western Railway Club.
†Associate editor of "Engineering News."

only about a year ago. This railway was a new one to enter the city, and the cost of land for its right of way and terminals was something appalling. The freight warehouse is a building five stories high, with a basement 16 ft. below the street level. The railway is on the street level. The warehouse is 384 × 255 ft. and is entered by six tracks, in groups of three, with a 20-ft. platform as high as the car floors on each side of each group. On the opposite sides of these platforms are the team roadways. Each set of tracks has three traversers, which are transfer tables running on transverse rails level with the track rails, the cars running up short inclines onto the traverser. It must be remembered that the cars are short, and weigh only 18 tons with full load, an 8-ton car carrying 10 tons as a maximum. For the inbound traffic, the two outer tracks are for unloading cars, the empty cars being shifted by the traversers onto the middle track. For the outbound traffic, the two outer tracks are for loading the cars, which are then shifted onto the middle track and run out into the yard. Cranes handle the freight on the platforms, and elevators are provided to carry freight up to the warehouse floors above. Across the front of the building runs a transverse track, with a turntable at the intersection of each longitudinal track. Thus the short cars can be easily transferred from one track to another. Two 20-ton hydraulic car elevators connect the yard tracks with the basement tracks, and a driveway with a grade of 1 in 28 (3.57%) leads from the entrance yard for teams to the basement. This incline is inside the building and has an arched entrance with rolling steel shutters. No engines are allowed in the building, the cars being moved by ropes, for which numerous hydraulic capstans are provided. Plans generally similar are in use at most of the large London terminals.

The writer is not aware of any American terminal having tracks on two levels, but there are terminals in which the roadway and tracks are on different levels. At Philadelphia the Philadelphia & Reading R. R. has depressed its tracks to eliminate grade crossings, and has built a brick freight house, 33 × 308 ft., with an upper floor for delivery of freight from teams at the street level. Six elevators, with platform 10 × 14 ft., carry the freight to the lower floor, where it is transferred to cars standing on the house track. For the transfer of very heavy freight, direct from wagons to cars, there is a traveling crane, spanning the track nearest the foot of the retaining wall and extending over the side of the parallel street above. This is shown in Fig. 1.

It is quite probable, however, that there are already cases where economy would well warrant the installation of tracks on two floors, the cost of land being greater than that of the additional building and equipment. Mr. E. P. Dawley, of the New York, New Haven & Hartford R. R., states that $2 per sq. ft. extra, above the cost of a one-story house, ought to give a good mill-construction slow-burning type of building two stories high. The arrangement would be easily established on a side-hill location, but could also be established in flat localities with comparatively little additional expense, and prove a profitable and economical investment. Coaling stations quite frequently have approaches of 5 to 6%, or even 10% for the loaded coal cars, which are pushed up by a small dummy car on the end of a cable, or by other suitable means. At coaling piers, etc., the loaded cars—with 30 to 50 tons of coal—are sometimes hauled up inclines of 25% to the top of the pier by cables. Similar methods could be used for the freight houses, and if the low level tracks were depressed 4 or 5 ft., the incline approach to the high level would be quite short.

Another novel and interesting form of freight terminal is of the loop type. At the terminal of the Harlem Transfer Co.,* at East 135th St., New York, the freight house is a hollow oval or ring, 188 × 158 ft., the building itself being 35 ft. wide. The paved court in the center is for teams. The circular house track has end curves of 90 ft. radius; concentric with it is the main switching track, with end curves of 104 ft. radius. On the curves the outer rail is elevated 2 ins. and the gage widened to 4 ft. 9 ins. As many as 11 cars (some loaded and others unloaded) have been hauled at one time around the switching loop of 104 ft. radius.

The foregoing descriptions of double-decked and loop terminals are intended to show the possibilities of applying these systems, separately or in combination, to many existing terminals when increase in capacity or reduction in area (or both) become imperative. Curves 50 to 90 ft. radius are used in many yards. With such curves, and with grades of 6 to 10% for incline tracks, it would seem that the available area may, in many cases, be worked to a much higher capacity than at present. The use of turntables may also be of advantage, especially in buildings. The writer, however, knows of only one case in which a turntable is used for switching work.

The Brooklyn Wharf & Warehouse Co. has two terminals in Brooklyn, N. Y., known as Fulton terminal and Atlantic terminal, where freight is handled for eight different railways. At the Atlantic terminal the sharpest curve is, outside rail 82 ft. radius, inside rail 77 ft. radius. The gage of this curve was 4 ft. 9 ins. when laid, but is probably 4 ft. 9¼ ins, at the present time. The curve is on the bulkhead running between the storehouses and piers, and when laid it was not thought practicable to elevate the outside rail. Considerable difficulty was found in handling cars on this curve, however, and soon after the outside rail was elevated 4 ins. Since then between 40 and 50 cars daily have been handled without difficulty. The engine frequently pushes or pulls seven loaded cars around this curve. The only time a link is used between the automatic couplers is when two 40-ft. cars come together and are being pushed, when it is necessary to place a short coupling bar between cars in order to keep the corners from hitting. At the Greenpoint terminal at Brooklyn, N. Y., operated by L. M. Palmer for a number of railways and steamship lines, the sharpest curves are of 90 feet radius, and a 2-ft. drawbar is used between 30-ft. cars to keep the corners from interfering.

The arrangement of passenger yards and terminals is more a matter of convenience than economy, the switching movements being comparatively limited. The track plan is a very important consideration in passenger station design, in order to provide ample facilities for train service, and to insure the prompt handling of the traffic, especially in an emergency, as at times of exceptional press of traffic. The amount of track required and its arrangement will, of course, depend upon the amount and requirements of the traffic. Stub-end tracks should generally be in pairs, with crossovers near the ends, so that the engine of an incoming train can be got out without waiting for its train. This is specially important where suburban traffic has to be provided for.

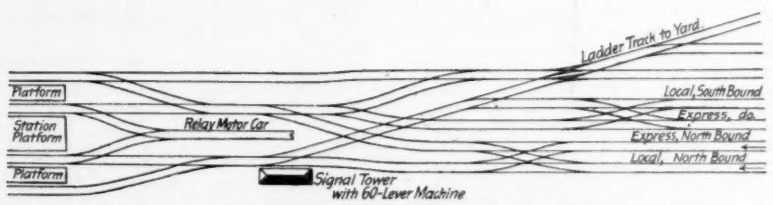


FIG. 2.—PLAN OF TERMINAL OF NORTHWESTERN ELECTRIC ELEVATED RY.; CHICAGO, ILL.

Fig. 2 is a plan of the northern terminal of the Northwestern Elevated Electric Ry., Chicago. This line has four main tracks, two for express and two for local trains, and the station has four tracks and three platforms. The daily schedule calls for a train in and out of the station platforms every 105 seconds. During the morning and evening rush trains sometimes get a few minutes off their schedule time, and trains are then frequently handled in and out of the terminal on 45-second intervals.

THE GERMAN RAILWAY IN SHANTUNG, CHINA.

By H. L. Geissel.*

Soon after the occupation of Kiao Chou by the Germans, the German Government ordered surveys to be made for the purpose of constructing a railroad in the Province of Shantung. When it was learned that no special engineering difficulties would be met with along the entire route of the intended line, and that even the bridging of the great rivers crossing the country would present no extraordinary difficulty, the Government granted a concession for the formation of the "Shantung Railway Company."

The railway, of which 145 kilometers (90 miles) are now completed, starts from the city of Tsingtau, which is situated at the foot of the southern promontory of the Peninsula of Laushan, and which is the seat of the Imperial Government, runs along the eastern shore of the Bay of Kiao Chou to the north, follows the coast, crosses a river on an iron bridge 200 meters in length and numerous smaller streams, after which it reaches, at a distance of 24 kilometers (15 miles), the Peishaho River, the border river of the German leased district. This river is to be crossed on a bridge 240 meters (787 feet) in length; work on this bridge is now under way. The line then turns to the northwest along the slopes of the mountains; it then crosses the Takuho River, which empties into the Bay of Kiao Chou and which requires a bridge of 180 meters (590 feet). From that point the railway turns to the south and reaches at a distance of 72 kilometers (44.7 miles) the first principal station, Kiao Chou. From this place the line takes a northwestern direction, crosses several rivers and reaches at a distance of 99 kilometers (61.5 miles) the city of Kaumi, and a little further on the border of the German territory. At 127 kilometers (78.86 miles) the railway reaches the larger city of Tchangling, runs over a chain of hills, crosses the Weiho, then theYuenho, when it ascends between the Weiho Valley and the great coal district of the Weih-Sien watershed. The coal district proper is reached 14 kilometers south of Weih-Sien, the terminus of the line to be constructed and operated according to the concession. A temporary line leads from Kiao Chou Station to the quay of the harbor.

The entire line is narrow gage. Although the roadbed has been laid out for double track all works are built for a single track line. The line is laid with rails weighing 30 kilograms (66.18 lbs.) per meter (39.37 inches), whilst iron ties of 50 kilograms (110 lbs.) are employed. The latter lie 86 centimeters (34 inches) apart. All the bridges are of iron and steel. The station buildings, with the exception of those at large places, are constructed as one-story buildings. The rolling stock so far provided consists of 10 locomotives of 30 and 50 tons weight, 90 platform cars, 80 coal cars, 50 covered freight cars, 10 chalk cars, 2 crane cars, 2 baggage cars, 2 second-class passenger cars and 6 third-class passenger cars. All locomotives as well as the passenger and baggage cars are provided with Schleifer air-brakes. Whilst the contracts for earth and masonry work, foundation and bridge work, etc., have been awarded to German contractors, minor works have been entrusted to Chinese contractors. As at the beginning of the present year 80% of the earth works and 45% of the masonry work was completed of the Tsingtau Kiao Chou line, it is hoped that the entire line—in spite of the present Chinese troubles—will be completed and opened for regular traffic at the beginning of 1901. Work is now being pushed on with great energy.

A GAS ENGINE ELECTRIC LIGHTING PLANT IN A PUBLIC LIBRARY BUILDING.

In the branch libraries of the Carnegie Institute at Pittsburg, which have been established through the generosity of Mr. Andrew Carnegie, an extremely compact and efficient electric lighting plant has been adopted in which the dynamo that supplies current is driven by a direct-connected gas engine. These plants were installed by the Westinghouse companies, and we have been furnished by them with a description of the plant in use at the Lawrenceville branch, from which the following is taken:

The building contains an auditorium seating 5,000 people, a book room, with capacity for 60,000 volumes, and several reading rooms, etc. The building is lit by 200 incandescent lamps of 16 and 8 c. p. The engine room, located in the basement, is 15 × 18 ft., and contains the generating set, consisting of a 25-HP. Westinghouse two-cylinder gas engine, direct-connected to a Westinghouse direct-current generator with a capacity of 150 amperes at 110 volts. The two machines are mounted on the same bed-plate, only 4 × 10 ft. The room also contains the switchboard, and in one corner is a small air compressor, which is belted to the gas engine at intervals, as required, for charging a tank placed in a cupboard in the engine room. The tank is connected to the cylinders of the gas engine through suitable valves, and the compressed air is used for starting the gas engine, as is ordinarily done in the Westinghouse outfits. In the cupboard covering the air tank is a small primary battery and induction coil which is used for igniting the gas and air mixture in the engine cylinders while starting. After the voltage of the generators has reached normal, the igniting battery is switched out, and the main current from the dynamo is used in the ignition mechanism, three incandescent lamps in

*"Engineering News, Dec. 22, 1898.

*233 South 4th St., Philadelphia.

series being used as a resistance in circuit with the induction coil.

The plant has been in operation nine months, and thus far no interruption of the service has occurred, no change in the igniters or any other part of the gas engine equipment having required repairs or renewal. The plant is in use for several hours every day carrying a considerable load, and it operates with great steadiness and a minimum of attention.

The building is heated by a hot-water system using natural gas as fuel, and this gas is also used in the gas engine. Were fuel economy an object it would seem to be practicable to utilize the hot water discharged from the hot water jacket of the engine in the heating coils, thus obtaining the same advantage of economy as is obtained in the steam engine by the use of the exhaust steam for heating purposes.

The great advantage of the gas engine plant in the elimination of the boiler, with all its attendant risk, cost of attendance and dirt and dust in handling fuel and ashes, make the system an ideal one for isolated electric plants. The two features which have prevented a larger use of gas engines in this field are the liability to break-downs and the noise and vibrations which were formerly considered inseparable from the gas engine. We are assured that these have been entirely overcome in the plant above described.

THE RECLAMATION OF RIKER'S ISLAND, in the East River, off 138th St., New York city, has been progressing for some years past and without cost to the city, as the workmen are prisoners from Blackwell's Island. The city bought this island in 1884 for $180,000, as a site for a new penitentiary, but no money was then available for its improvement. After some more or less efficient attempts to reclaim the submerged lands, the present Commissioner of Correction, Mr. Lantry, proposed that the filling-in could be done by the Street Cleaning Department with ashes collected, with the cribbing necessary supplied by the Dock Department and the labor coming from the House of Correction. This plan has been carried out in part and the land area of the island has been greatly extended, roads laid down and hillocks leveled. On top of the ashes of the reclaimed land a top soil 3 or 4 ft. deep is being now dumped.

THE HEALTH RECORD OF THE NAVY AND MARINE Corps, says Surgeon-General W. K. Van Reypen in his annual report for 1900, shows a marked decrease in the ratio of admissions to the sick list as compared with the previous year. The ratio per 1,000 for 1899 was 783.03, as against 871.69 in 1898, 838.53 in 1875, 775.75 in 1896 and 748.24 in 1897. The average strength of the active list in 1899 was 20,819 men and the medical returns cover a force of 20,113 men. The number of persons invalided from service, including retirement of officers for disability and transfers to the Government Hospital for the Insane, was 542 in the year, or a ratio of 26.03 per 1,000. In 1898 this ratio was 36.85 per 1,000. The death rate was 7.35 per 1,000, or 4.56 from disease and 2.79 from injury.

ANNUAL MEETING OF THE NATIONAL IRRIGATION CONGRESS.

The ninth annual session of the Congress was held at Chicago, Nov. 21 to 24, the meetings being held at the Central Music Hall and the Auditorium. The first meeting was opened on the evening of Nov. 21, when Mr. Elwood Mead, M. Am. Soc. C. E., President of the association, delivered an address in which he showed that to secure water for the arid regions and to reclaim these regions by the distribution of water are matters not only for the state governments, but for the national government to deal with. In these regions the question of water is of more importance than the land, but the various state laws are so inadequate and conflicting as to make it necessary for some higher authority to establish general laws which will cover the whole question.

The best results in irrigation have been achieved where land titles and water rights were united; but we have in this country a system which divorces these two elements, since the general government controls the land and the states control the water supply. The last two meetings of the irrigation congress have shown the influence of the work being done by the national government. Public sentiment in the West is becoming actively exerted in its favor by its extension and to secure appropriations of money from the national treasury for the construction of storage works and the building of canals of too great magnitude or cost for private enterprise. If this is done it should be under such conditions as will unite with the ownership of land a share in the stream on which its value depends. This would surely mark the beginning of an economic reform of immense significance. The benefits of such united ownership will be more potent than precept or argument and will insure the downfall of speculative control of streams which divided control of land and water has made possible.

Addresses were also made by Mr. George H. Maxwell, Chairman of the National Executive Committee of the congress, and by Mr. J. M. Wilson, of Nevada. An abstract of Mr. Wilson's remarks is given below:

Before the discovery of gold in California, the territory west of the Missouri River was an unknown country, and much of it was believed to be an inhospitable desert. As knowledge of the profits and of the certainty of crops under irrigation became known, wherever the lands and water could be brought together by individual effort, or by the co-operation of neighbors, ditches were dug. The best opportunities for such individual efforts were on the smaller streams. The cost of works for diverting water from the large streams was so great that for many years little attention was given to them. But the success of some of the larger co-operative canals, notably those in Colorado, Utah and southern California, was so marked that the supposed profits of canal building began to attract the attention of the promoter and the capitalist. Millions of dollars were expended in irrigation construction, some of it wisely, more of it unwisely. To many of the companies came disappointment. The expenses of building in many cases outran the estimates. After the canal was built, floods and storms had to be reckoned with and often the first cost had to be supplemented with a heavy outlay for maintenance.

Where these canals have been well located and properly managed, they have been of great benefit in the development and improvement of the lands under them. But as few of them have been dividend earners, it is certain that outside of the ditches already constructed, little further progress toward the reclaiming of arid lands need be expected through the efforts of the capitalist. The method pursued by the Department of Agriculture in its investigations has been to secure in each state where irrigation is practiced a competent observer, centrally located, preferably at the experiment station. The observer was instructed to select the more important irrigation streams of the state and to make a study of the workings of the state law as applied to conditions on these streams. This study includes the collection of facts concerning the filings, the examination of court records in the water cases, the method of regulating the diversion of the water from the streams, the forms of contracts used by water users and canal owners. Special attention is given to the methods of measurement and the duty of water. By duty of water is meant the volume necessary to irrigate an acre of land. Where irrigation is practiced it is necessary that this should be known, at least, approximately. Without such knowledge satisfactory contracts cannot be made for the delivery of water, and until this is determined legislation cannot proceed intelligently, nor courts decide justly.

At the meeting on Nov. 22, the most important matter discussed was in regard to the relation of the government to the project for establishing storage reservoirs and distributing the water therefrom for irrigation purposes. Two opposing views were taken by different speakers: One was to the effect that the national government should merely build the dams and other works under direction of the corps of engineers of the Army, as in the case of river and harbor works, and that the distribution of the water and the construction of distributing canals, ditches, etc., should be left to the states and to private enterprise. The other view, which was the more strongly supported, was to the effect that the government should control both the land and the water. This discussion, which occupied the greater part of the morning and afternoon sessions, was started by a paper on "The Relations of the General Government to Reservoir Construction," by Capt. Hiram M. Chittenden, Corps of Engineers, U. S. A. The conclusions of this paper were as follows:

These two principles should be given corporate form in the resolutions which this association may present to Congress asking for government aid in the construction of storage reservoirs:

(1) That the water so stored shall be for the free use of the people, subject only to such laws and regulations as may be in force in the states through which they flow.

(2) That, in thus advocating the construction of reservoirs by the federal government to conserve the waste waters of the arid regions, this association disclaims any purpose of drawing the government to the policy of constructing irrigation works or of enacting legislation for the control of water used in irrigation, as in its judgment such matters should be left exclusively to the states at present.

And in proposing a law for the appropriation of money to build any reservoir, particularly the first which may be built, it should contain the following provisos:

(1) That the water so stored shall be for the free use of the people, and shall be released under regulations to be established by the Secretary of War (or Interior, as the case may be).

(2) That the waters so released shall, after flowing off the government reservoir property, become a part of the stream in its natural condition and be subject to the laws and regulations of the state or states through which they flow.

(3) That the construction of this reservoir, or of any other that may hereafter be built, shall not in any way commit the government to a policy of constructing irrigation works, nor of controlling the distribution of the waters which flow from such reservoirs.

The paper pointed out that proposals for the government to undertake works for the storage of water for irrigation have been in the past largely regarded with disfavor, but that expenditures for such work would be in the same class as those for river and harbor improvement and levee work. The levees are built primarily as a protection to life and property, and only secondarily as an aid to navigation. Several speakers endorsed the above views as to the expenditures, but went farther, claiming that as the government is a large land owner it should rightly undertake the distribution as well as storage of water in order to prepare its lands for settlement. Some of the speakers thought that if the distribution works were left to corporate enterprise, there would be danger of large land monopolies and frauds, as under the Desert Land act and the Homestead act. Others, however, considered that there was no danger of monopoly, as the development of irrigated land is rather by the high cultivation of small areas, so that in the Colorado farming districts the land companies are selling their lands and large farms are being subdivided. Capt. Chittenden, in closing the discussion, stated that his opinion is that the government should undertake those works, such as reservoirs and main or high-line canals, which are beyond the capacity of private enterprise. The association should confine itself to this point to start with, and not confuse it with other matters of less importance. He thought that if this point was pressed energetically a bill could be passed by Congress this winter.

Other papers read at the afternoon session were as follows: "The Public Lands, and their Reclamation and Settlement," by Thomas Knight, of Kansas City; "Irrigation Resources of Montana," by Prof. S. Fortier, Director of the Montana Experiment Station; and "Co-operative Canals and Irrigated Homes," by I. D. O'Donnell, President of the Farmers' Canal Co., of Billings, Mont.

In the evening an illustrated lecture on "Forestry as a Business" was delivered by Mr. Gifford Pinchot, Forester of the U. S. Department of Agriculture. Prof. Willis Moore, Chief of the U. S. Weather Bureau, also made an address in regard to the value of the snow and frost predictions of the Bureau to the farming communities. Great success has attended the measuring of snowfall along the mountain ridges of Wyoming, Colorado, Montana and New Mexico during the fall and winter for the purpose of determining the probable supply of water from this source during the coming seasons. Last April the first bulletins were issued from reports rendered by the directors in charge of the several section centers, and it has been shown that the forecasts made last spring as to the probable supply of water were fully verified in each case. Every state and territory now has from 50 to 100 daily measurements of precipitation and temperature. Letters on the subject of irrigation and of the relations of the general government to this question were sent by Gen. Nelson A. Miles, U. S. A., and by Governor Roosevelt, of New York. The conclusions presented by the latter were as follows:

Without pretending to outline definitely a working scheme, I venture to point out that without the attainment of the following objects your plans must measurably fail:

(1) Government study of the streams upon which your plans depend.

(2) Government construction and control of great irrigation plants.

(3) The preservation of forests by the extension of the forest reserve system, and hence of government control of the forests.

(4) National protection and use of the forests under expert supervision.

(5) Private owners of forests in the West and East alike should understand that timber can be cut without forest destruction (the Department of Agriculture will tell them how), and that the ownership of water rights in the arid country and of forest lands anywhere entails public as well as private duties and responsibilities.

On Nov. 23 the papers presented at the morning session related more especially to the agricultural and social side of the irrigation question: "What the National Irrigation Association Stands For," Wesley A. Stuart; "Practical Irrigation," by S. M. Emery, President of the Montana Horticultural Society; "Irrigation and Increased Production in Humid Climates," by Prof. F. H. King, Wisconsin Agricultural Experiment Station, and "The Subjugation of the Deserts," by Mr. John H. Smith, of Salt Lake City. At the afternoon session the papers were mainly in regard to the relations between forestry and irrigation. A letter from Hon. James Wilson, Secretary of Agriculture, was read, and Mr. Henry James, Editor of "The Forester," made a brief address.

A paper on "The Water Supply of Cities" was read by Mr. J. W. Toumey, of the Yale Forest School, but the title is rather misleading, as the paper referred exclusively to forests and forest preservation in relation to industries and water supply, the forests not only acting as distributors, but also greatly reducing the loss by evaporation as compared with bare ground. With the floods incident to deforested lands, the water often carries a high percentage of sediment, which is a serious difficulty in the conduct of irrigation works. At Johnstown, Pa., owing to a shortage in water supply, the entire watershed (covered with forest) has been purchased, and a series of storage reservoirs will be established. In this way a permanent water supply will be assured, and in addition there will be a steady revenue from the timber crop if the forest area is properly administered. In the discussion a number of speakers referred to the question of storing flood waters. One gentleman from Arizona stated that in consequence of deforestation the water supply for a certain irrigation canal system has decreased to such an extent that some of the lands cannot now be watered, and the company has to face an expenditure of $2,000,000 for a reservoir dam. This, however, will not afford permanent relief unless some steps are taken to preserve the forests in the drainage area. Another speaker from the same state remarked that during the present month there has been an unusual rainstorm, causing floods which ran to waste and overflowed some of the irrigation canals, doing probably more harm than good. Some remarks on "Irrigation and Agricultural Development" were made by Mr. L. G. Powers, Chief Statistician in Charge of Agriculture, Twelfth U. S. Census.

The Committee on Permanent Organization announced the selection of officers as follows: President, Thomas F

Walsh, of Washington; Vice-Presidents, J. Bradford Prince, of New Mexico, and F. B. Thurber, of New York; General Secretary, H. B. Maxson, of Chicago. In the evening, the President delivered an address, and Mr. Frederick H. Newell, Hydrographer of the U. S. Geological Survey, gave an illustrated lecture on "Our National Irrigation Resources." Papers on "Government Irrigating Works in India and Egypt," by Dwight B. Heard, and "The Reclamation of Arid America," by Gen. H. G. Otis, were read in the absence of their authors. The primitive irrigation methods of the Indians in Arizona were described by Mr. J. B. Whittemore, and Mr. Milton Whitney, Chief of the Division of Soils, U. S. Department of Agriculture, spoke on "Alkali and Its Remedies." Addresses were also made by some of Chicago's business men. The following are some extracts from Mr. Newell's lecture, above mentioned:

One-third of the whole United States, exclusive of Alaska and outlying possessions, is vacant and at the disposal of Congress. For the most part it is open to homestead entry and settlement, and much of it consists of land possessing great fertility except for the lack of water. From mountain masses come perennial streams whose waters are now used to a small extent to moisten the parched lands. At intervals there occur local storms or floods inundating large tracts. There is ample water for the reclamation of a considerable portion of this arid land, if it could all be saved and put to use, and attempts have been made by individuals and by corporations to construct ditches, canals and reservoirs to supply the lack of moisture. As a rule the smaller works taking water from perennial streams have been not only successful, but sources of great profit to the owners. The larger works, however, almost equally without exception, prove financial failures and their owners have become bankrupt. The great works, built in the hope of securing a certain and permanent revenue drawn from the farmer have impoverished the owners and the latter have unwillingly become benefactors of the public.

The lesson is being slowly but certainly taught that reclamation on a large scale cannot be made a source of profit except under extraordinary combination of circumstances. The great storage reservoirs and canals are comparable in one sense to lighthouses and harbor improvements; they are necessary and worth far more than they cost, but under existing state of civilization they cannot be made to contribute exclusively to the welfare of the builders. The indirect gain or unearned increment of value is so widely diffused that the general public reaps the largest reward.

We are confronted with a situation where there is a vast amount of fertile land to be reclaimed and considerable quantities of water to be conserved and brought to this thirsty land. To bring about this happy result it is impossible to trust to speculative enterprise, because of the fact that profit cannot be made in the construction of a work, unless the population becomes tenants of a great land-owning monopoly. Public funds must be wisely used in the construction of works of reclamation. This must come about when the people of the country are fully conversant with the facts. These facts are being obtained by the investigations of the U. S. Geological Survey in the water resources of the country, and the extent to which the arid lands can be redeemed by irrigation.

There was but a small attendance at the morning meeting on Nov. 24. Mr. John S. Couper described the proposed National Minnesota Park, a bill for which is expected to be passed by Congress this winter. The park will have an area of 1,297 sq. miles, of which 325 sq. miles are water surface. It is to be established in order to preserve some remnant of the great pine forest regions which have been devastated by lumbering operations.

After a somewhat acrimonious discussion as to the location of the next meeting and the policy of holding two meetings next year, it was decided to hold a summer meeting at Colorado Springs, Colo., about the time of the Trans-Mississippi Congress, and another meeting at Buffalo, N. Y., in the autumn. Resolutions were adopted as follows:

(1) We urge upon Congress that national appropriations commensurate with the magnitude of the problem should be made for the preservation of the forest and the reforestation of denuded areas as natural storage reservoirs and for the construction by the national government, as a part of its policy of internal improvement, of storage reservoirs and other works for flood protection and to save for use in aid of navigation and irrigation the waters which now run to waste and for the development of artesian and subterranean sources of water supply.

(2) The waters of all streams should forever remain subject to public control and the right to the use of water for irrigation should inhere in the land irrigated and beneficial use be the basis, the measure and the limit of the right.

(3) The work of building the reservoirs necessary to store the floods should be done directly by the government under existing statutes relating to the employment of labor and hours of work and under laws that will give to all American citizens a free and equal opportunity to get first employment and then a home on the land.

(4) We commend the efficient work of the various bureaus of the national government in the investigation of the physical and legal problems and other conditions relating to irrigation, and in promoting the adoption of more effective laws, customs and methods of irrigated agriculture, and urge upon congress the necessity of providing liberal appropriations for this important work.

The afternoon session was devoted to brief addresses by business men on the industrial and commercial importance of irrigation. In the evening there was an illustrated lecture on "The Water Supply of the Great Plains," by Mr. N. H. Darton, U. S. Geological Survey; and an address on "Labor, Land and Water; the Solution of a Mighty Problem," was delivered by Mr. George H. Maxwell, Executive Chairman of the National Irrigation Association.

THE TERMINAL IMPROVEMENTS OF THE CHESAPEAKE & OHIO RY., AT RICHMOND, VA.

(With two-page plate.)

An extensive piece of railway terminal improvement was undertaken at Richmond, Va., some time ago by the Chesapeake & Ohio Ry., and is now well advanced toward completion. This work includes a long line of viaduct, a large portion of which is over and parallel to the axis of the James River, and also a new union station and trainshed. The railway company's tracks within the city limits were originally carried by a timber trestle in the city streets, and had a grade of about 2%. This grade limited the seaboard traffic, all of which of necessity passed over the line, and required to overcome it an average of three locomotives for every 50-car train, which was the average train hauled to and from the city by one locomotive. The viaduct which is now being built is designed to remove this limit, and to secure a freer movement of the trains within the city generally. It should, perhaps, be noted here also that while the improvements will be greatly to the benefit of the city, they were projected and are being carried out wholly on the initiative of the railway company.

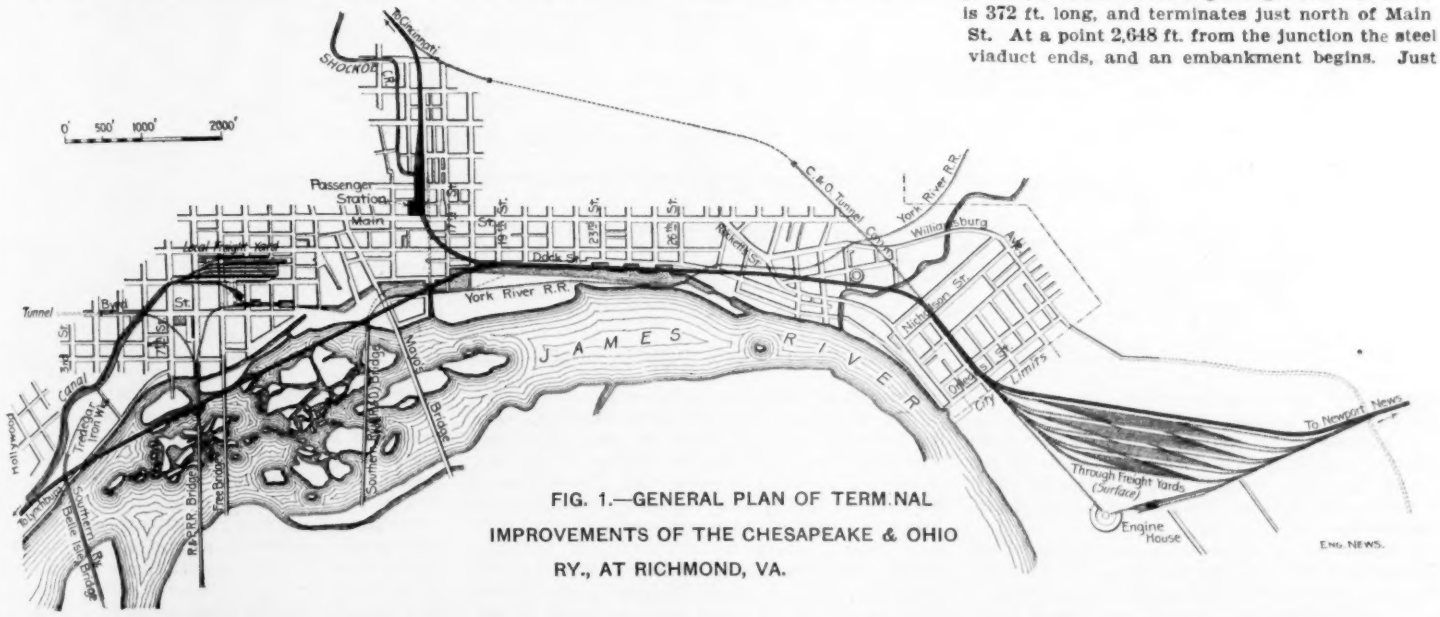


FIG. 1.—GENERAL PLAN OF TERMINAL IMPROVEMENTS OF THE CHESAPEAKE & OHIO RY., AT RICHMOND, VA.

LOCATION AND GENERAL DESCRIPTION OF THE VIADUCTS.

Fig. 1 is a map of the Richmond water front, showing the location of the new union station and of the viaduct line. The new line begins at the city limits on the east, and for 800 ft. between Orleans St. and Nicholson St. it consists of an earth embankment about 14 ft. high. In this distance there are three street crossings, each consisting of a solid floor plate girder bridge carried on concrete abutments. These bridges are 40 ft. and 50 ft. in span.

At Nicholson St. the viaduct proper begins. The first 700 ft. of the viaduct is on a 6° curve, after which there comes a tangent 1,600 ft. long, reaching to the west side of Rocketts St. At this point the viaduct ends and the line enters a cut 300 ft. long, which is the only section of the road where the tracks rest directly on the natural ground. From the end of the cut the line continues on a viaduct up Dock St., crossing two quays and three slips, to 19th St., which is the point of junction of the depot line and the main or river line. This section of the line is about 3,000 ft. long. The river line leaves the junction point on a 3° curve, about 900 ft. long, across the corner of a dock, and then crosses the depot and yards of the Southern Ry., on a tangent, passes the James River Bridge of the same railway near its north end, and strikes the bank of the James River, up the channel of which it runs, crossing over the free highway bridge and under the Richmond & Petersburg R. R. bridge, to the point of curve near the river wall at the Tredgar Iron Works. The length of the viaduct along the river is 4,900 ft. After leaving the river there is a 1° curve 1,700 ft. long, at the end of which a junction is made with the present tracks of the James River Division of the Chesapeake & Ohio Ry. The total length of the line just outlined is 13,910 ft., or about 2.63 miles, of which 800 ft. is embankment, 300 ft. is cut, and 12,810 ft. is steel viaduct.

The depot line leaves the Dock St. tangent of the river line on a 5°-55′ curve, which crosses 18th St., and at 17th St., compounds to a 10° curve at a point 1,244 ft. from the beginning. This 10° curve is 372 ft. long, and terminates just north of Main St. At a point 2,648 ft. from the junction the steel viaduct ends, and an embankment begins. Just north of Main St., and between the tracks of the Seaboard Air Line and the Chesapeake & Ohio Ry., is located the new Union Passenger Station, which is described further on.

VIADUCT FOUNDATIONS AND ACCESSORIES.

The portion of the viaduct on land is of the regular elevated railway construction, and the foundations consist of column pedestals and of abutments at street crossings. Both the piers and abutments were made of concrete composed of 1 part Portland cement, 2½ parts sand, and 6 parts broken stone or gravel, for the coarser work; and of 1 part Portland cement, 2 parts sand, and 5 parts of broken stone for the better work. The copings and cappings are of 1 part Portland cement, 2 parts granite screenings, and 3 parts of ¾-in. crushed granite. Where the work is above ground there as a 1-in. facing of mortar composed of 1 part Portland cement and 3 parts sand. In construction the facing mortar is first placed against the inner face of the mold and then the

concrete backing is placed and the two are rammed together. The method adopted in placing the facing mortar is the one which is used on the Illinois Central R. R., and which is described as follows in the specifications of that railway:

> A piece of sheet iron 6 ins. in width (the height of one course of concrete), and of any convenient length, say from 6 ft. upwards, having small angle irons, the projecting leg of which shall be 1½ ins. in width riveted to its face, at intervals of about 2 ft., and provided with handles standing above the upper edge at or near each end shall be furnished. . . . This piece or iron plate, if placed with the projecting angles against the face of the mold, will leave a space of 1½ ins. between it and the mold. This space shall be filled with mortar required for facing, which mortar shall be mixed in small batches from time to time as needed for the work. When the space between the iron plate and the mold is filled and tamped with a shovel or other tool, to insure complete filling of the whole space between the iron plate and the face of the mold, and when the layer of ordinary concrete is backed up against this iron plate, it is to be withdrawn by means of the handles and the whole mass of concrete rammed in one uniform layer. . . . Mortar should be of a consistency so that it will flow somewhat freely. At the same time this mortar must not be made so thin that the crushed stone may be forced through it in the process of ramming.

It will be noticed that the Illinois Central R. R. specifications call for a 1½-in. facing, but that a 1-in. facing was used on the work which is being described.

For underground work the concrete was made of 1 part natural cement, 2 parts sand, and 4 parts broken stone, or else of 1 part Portland cement, 3 parts sand, and 7 parts broken stone.

The concrete column pedestals were founded on piles in poor soil and on piles and grillage in both poor and soft soil. The bearing power of the piles was calculated according to Engineering News formula. All bearings were figured for the sum of the dead load of the structure, the weight of the concrete, the total live load, and one-fourth of the live load for impact. A little under 4,000 lbs. per square foot was the load assumed for calculating the area of the pedestial basis. Fig. 2 shows the pedestal and grillage for a 16-pile foundation.

All pedestals are capped with granitoid and have anchor bolts built into the masonry. Where there is no low bracing in either direction, four anchor bolts and an octagonal anchor plate were used, as shown by Fig. 3, the bolts extending 5 ft. into and 1½-ft. above the masonry. Where there is low bracing in one direction two anchor bolts and a rectangular base plate are used, the bolts having dimensions identical with those of the four-bolt anchorages. In case there is low bracing in both directions, two anchor bolts and a rectangular base plate are used, the bolts extending 4 ft. 11 ins. into the masonry and 2 ins. above, as shown by Fig. 4.

In a few instances a special foundation construction was employed for the pedestals. Where the line passes over the Richmond & Danville freight depot, the columns near the walls of the depot are founded on pedestals resting on steel grillages. By adopting this construction an excavation only 4 ft. in depth, instead of the usual depth of 15 ft. to 16 ft., was required to get the proper bearing, and the risk of caving and damage to the building walls was greatly reduced. In another instance, a 3 × 5 ft. stone-box sewer passed through one pedestal, and close alongside another. Steel rails were used to form the top of the sewer where it passed through the first pedestal and the masonry of the second pedestal was constructed to form one side of the sewer where it passed by.

Before leaving the concrete substructure construction it should be noted that where skew street crossings occurred the abutments were squared up with the axis of the bridge, as shown by Fig. 5, which gives the details of the abutment where the elevated viaduct line ends and the 300-ft. cut previously mentioned begins.

THE RIVER VIADUCT.

The portion of the viaduct line which extends along the bed of the James River is a pin-connected, deck truss structure resting on masonry piers. There are altogether 29 spans ranging from 120½ ft. to 133½ ft. in length. Full details of one of the 133½-ft. spans are shown by Fig. 6. It will be observed that the distance from the top of the pier to the base of rail is 24½ ft. This depth is kept constant throughout all the spans whatever their length.

The piers which carry the spans are built in pairs, a separate pier for each truss; each pier being 5 × 10 ft. in plan at the coping, with a batter of ½-in. per foot in all directions, and varying in height from 25 ft. to 45 ft. All the piers are of Kentucky limestone except those for the Richmond & Petersburg bridge, which are of granite.

Where the river portion of the viaduct line crossed the Richmond & Petersburg railway bridge and the old James River highway or free bridge, changes had to be made in these structures. At the Richmond & Petersburg bridge a 140-ft. pin-connected deck span was replaced by three plate girder spans in order to permit the new line to pass underneath. At the old free bridge the viaduct makes an overhead crossing with a clearance of only 13 ft., and it was necessary to change the grade of a portion of the highway bridge. A solid floor was provided for this crossing, at three street crossings, at the Seaboard Air Line Ry. crossing, and at the Tredgar Iron Works. With one exception these floors are only 12 ins. thick from base of rail to the clearance line. Fig. 7 shows the details of the solid floor for the free bridge crossing, and the construction at the other crossings is substantially the same. The construction shown needs very little description, except to note that the rails rest on channel longitudinals, which are placed back down on the floor troughs. The troughs are rectangular, made of plates and angles, and are 8¼ ins. deep. An asphalt filling is used to reduce the noise of passing trains.

The erection of the viaduct was chiefly interesting on account of the immense steel traveler designed for the work by the Pencoyd Iron Works. The conditions made the use of a traveler preferable to timber falseworks. From the end of the work, where the material had to be delivered, the piers increase gradually in height from 25 ft. to 45 ft. at the opposite end, thus preventing in a large measure the contractors from using the same falseworks for successive spans. In addition the river bed under the viaduct is covered with boulders, making the erection of timber falseworks rather expensive. As stated, directly above, the spans of the river viaduct are 120½ ft. and 133½ ft., and the traveler was designed with a reach which would cover the length from pier to pier of the longest span. Stated exactly, the total length of the traveler is 213 ft. 8 ins., its reach from the center of the forward track to the center of the front end support is 141 ft. 11½ ins. The traveler is constructed entirely of steel, as clearly shown by Fig. 8, and is provided with traveling carriages and ample operating machinery, which is also shown by Fig. 8. The strains on the different members of the traveler were carefully calculated, and are as shown by Fig 8. The most notable feature of the design is, perhaps, the peculiar curving of the chords over the main supports which makes a uniform distribution of the total load on these three supports. The various other details of the traveler construction are fully shown by the drawing and need not be described further.

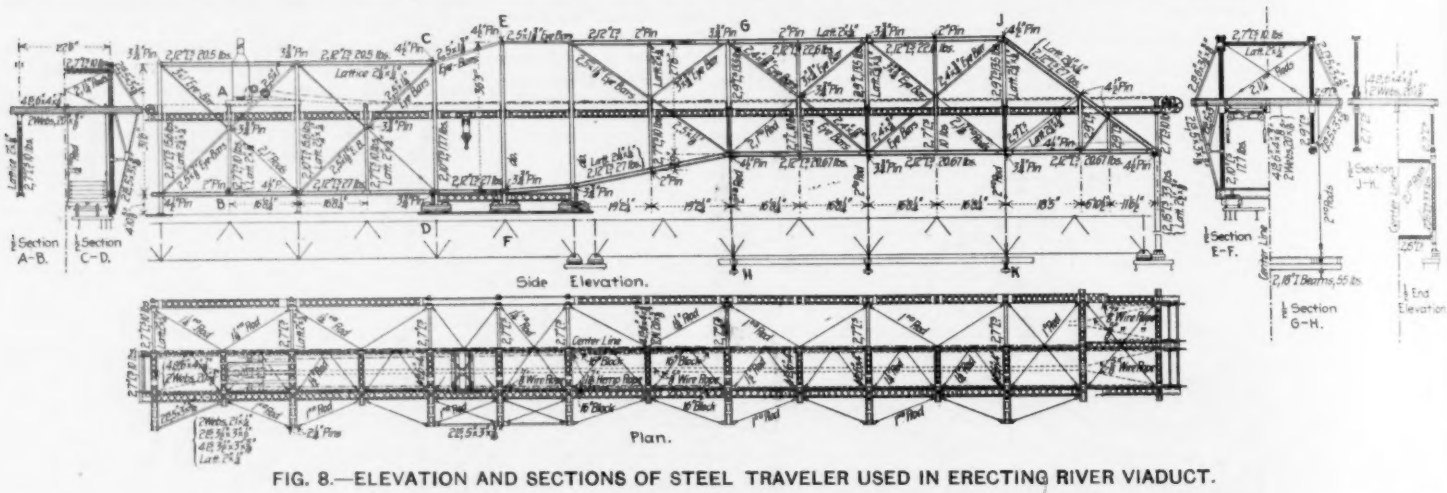


FIG. 8.—ELEVATION AND SECTIONS OF STEEL TRAVELER USED IN ERECTING RIVER VIADUCT.

NEW UNION STATION.

The new union station, located as shown by Fig. 1, will serve the Chesapeake & Ohio and the Seaboard Air Line railways. It consists of a head-house 105 × 97 ft. in plan, and of a trainshed 530 ft. long, having a roof span of 116½ ft. c. to c. of side columns. Fig. 9 gives a plan and several sections of the head-house and train shed. There are six tracks under the shed and three tracks outside, arranged as shown by Fig. 9. It will also be observed from this illustration that the train shed floor is 28 ft. above the level of Main St., upon which the head-house fronts. The ticket office is 8 ft. above Main St., and may be reached by steps or by an inclined driveway. Broadly speaking, the general arrangement of the station resembles that of the Philadelphia & Reading terminal station at Philadelphia, Pa.

The head-house is four stories high. The lower story is built of Kentucky freestone, and the three stories above that of old gold Pompeiian brick and terra cotta. The roof is covered with Spanish tile. The general waiting-room is 50 ft. square; the ladies' room is 20 × 30 ft.; the restaurant is 20 × 25 ft.; and the lobby between the main waiting-room and train shed is 34 × 80 ft. The architects for the station were Wilson Bros., of Philadelphia, Pa., and the contractors were the Pencoyd Iron Works, of Pencoyd, Pa., for the train shed, and J. E. & A. L. Pennock, of Philadelphia, Pa., for the head-house and other work.

The contractor for the substructure of the viaduct, the earthwork, masonry, pile-driving, dredging and everything but the steelwork, was Shanahan, Serpell & Co., of Louisville, Ky. The steelwork for the viaduct, train shed and the approaches to the train shed was manufactured and erected by the Pencoyd Iron Works, of Pencoyd, Pa. Mr. F. W. Scarborough, Assoc. M. Am. Soc. C. E., Engineer of Bridges and Signals, Chesapeake & Ohio Ry, was the engineer of the work. The information from which this description has been prepared was partially collected during a personal visit of a member of the staff of Engineering News to the work, and partially furnished by Mr. Scarborough and the Pencoyd Iron Works.

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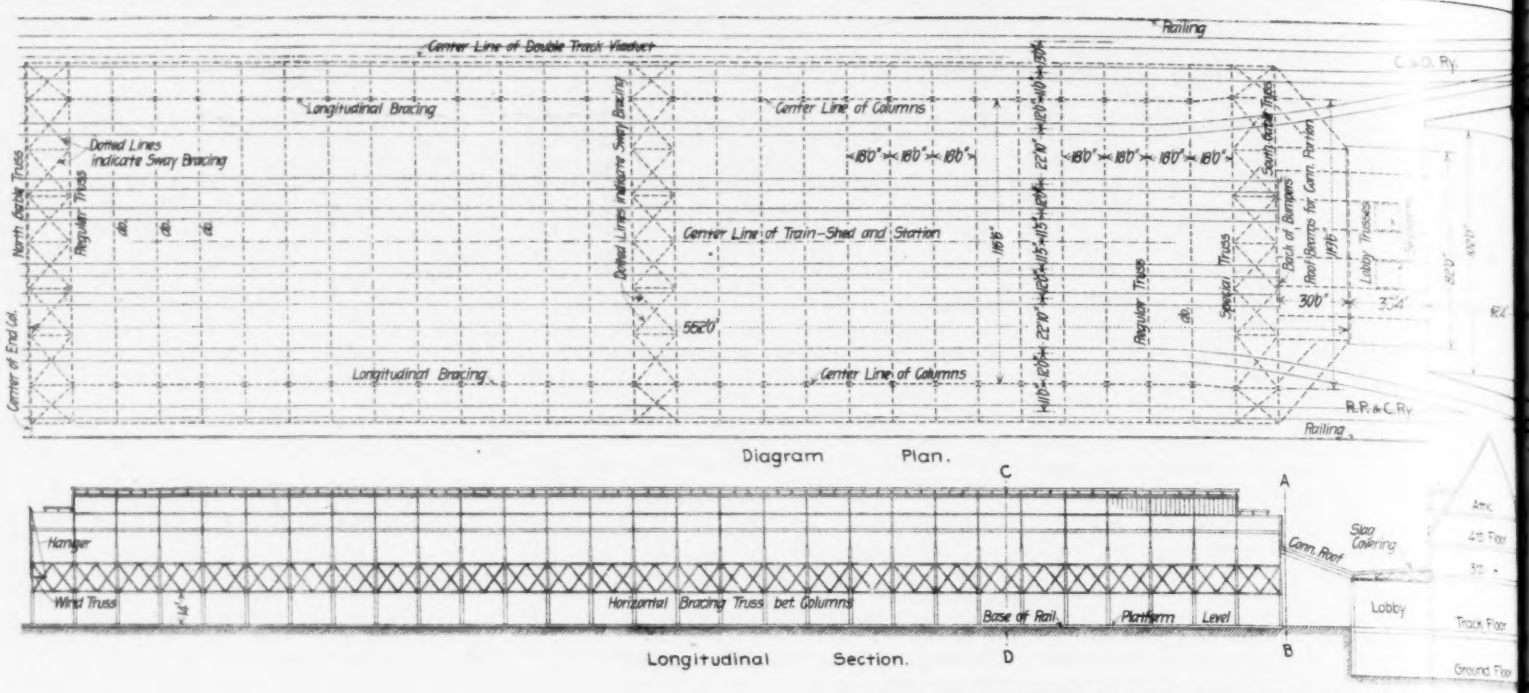


FIG. 9. PLAN AND SECTIONS OF UNION STATION AND TRAINSHED

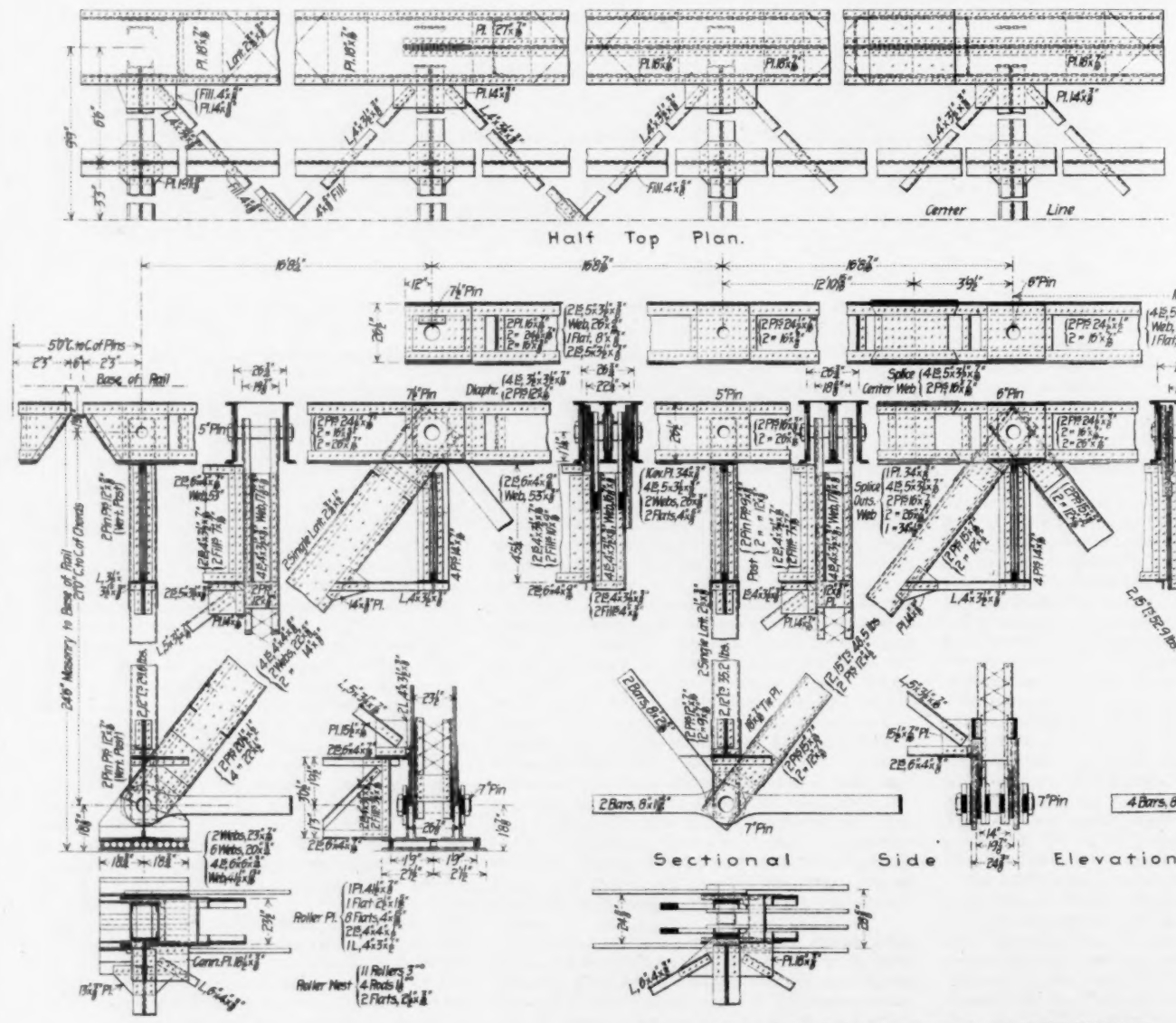
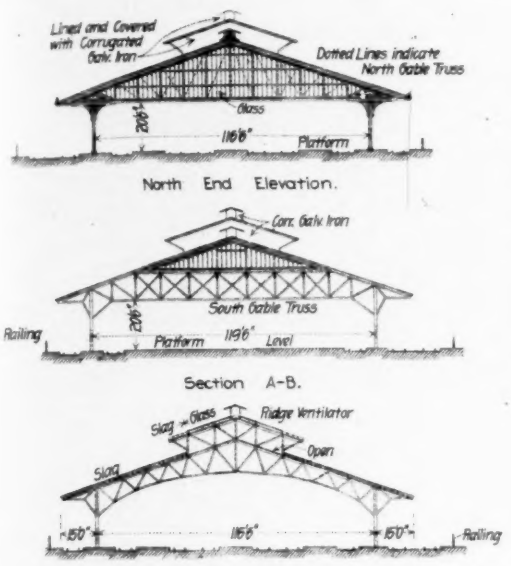


FIG. 6. DETAILS OF 133⅓-FT. DECK SPAN, RIVER VIADUCT.



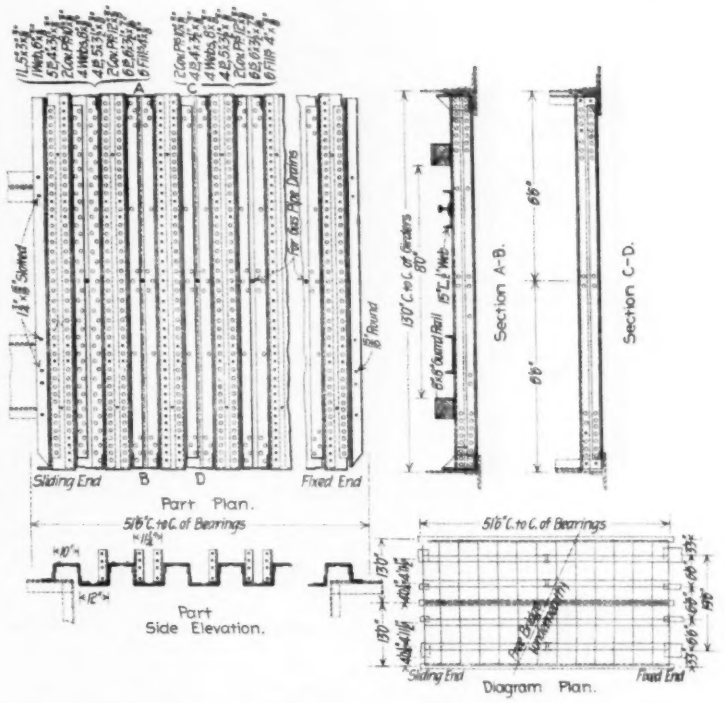
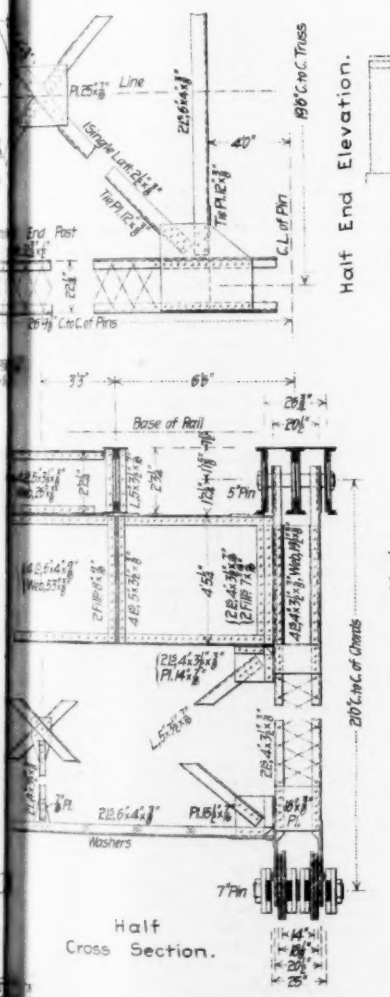
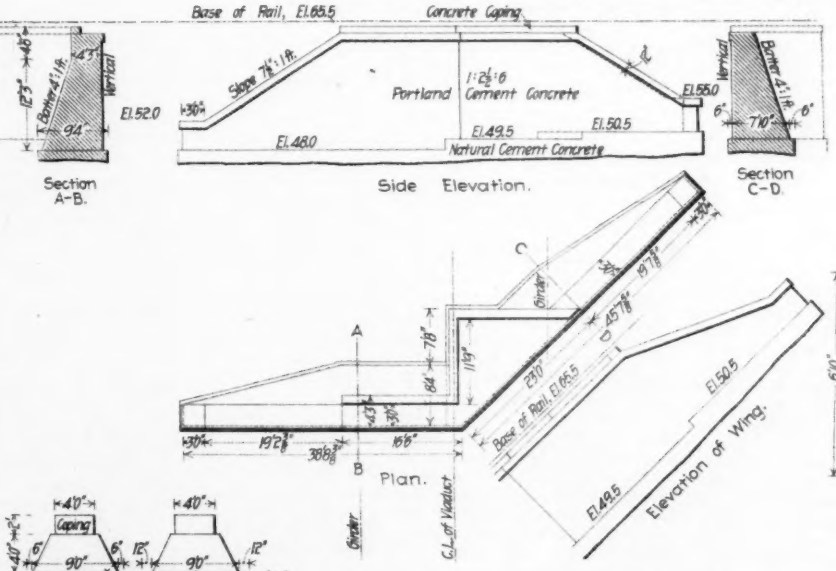


FIG. 7. SOLID TROUGH FLOOR CROSSING OVER JAMES RIVER FREE BRIDGE.





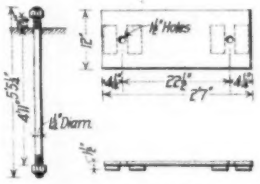


FIG. 4. TWO-BOLT COLUMN ANCHORAGE.

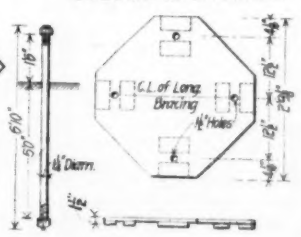


FIG. 3. FOUR-BOLT COLUMN ANCHORAGE.

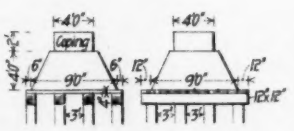


FIG. 2. COLUMN PEDESTAL AND FOUNDATION.

FIG. 5. CONCRETE ABUTMENT FOR ROCKETTS ST. OVERHEAD CROSSING.

CHESAPEAKE & OHIO RY. TERMINAL IMPROVEMENTS,

RICHMOND, Va.

F. W. Scarborough, Assoc. M. Am. Soc. C. E., Engineer in Charge.

CHAS. HART, LITH., 88 VESEY ST., N. Y.